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ANOMALIES OF THE COLON: THEIR ROENTGEN DIAGNOSIS AND CLINICAL SIGNIFICANCE[1]

RÉSUMÉ OF TEN YEARS' STUDY[1]

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THIS study is based on a series of approximately 2,000 consecutive cases in which the form and function of the colon was observed roentgenologically. This series, in turn, constitutes a part of a basic group of approximately 4,000 private patients complaining of various digestive symptoms, thus furnishing a homogeneous background for the conclusions presented. The statistical method was employed throughout in the belief that this would yield results most likely to be objective in nature and most open to confirmation or refutation by others.

By way of preliminary survey 3,000 unselected cases of the basic group were analyzed for the general incidence of the more common symptoms of "indigestion." These figures are presented in Table I, and will be used throughout the paper as a standard of comparison for the anomalies about to be described. Having no preconceived notions to establish, the chief emphasis will be placed on the facts themselves, leaving the temptation to speculate on their significance in the background. Nevertheless, before proceeding to details it may be of value to formulate the following generalizations that have grown out of this study:

1. Anomalies may be regarded as expressions of organic constitutional inferiority or, in other words, points of actual or potential weakness in the body structure.

2. Anomalies may be divided into the following three classes: Those incompatible with life (congenital atresia of the bile ducts); those compatible with life but not with robust health (high grade visceroptosis); those compatible with life and health under favorable circumstances (uncomplicated Meckel's diverticulum).

3. The general tendency seems to be for the body as a whole to compensate for the presence of an anomaly. Hence symp-

TABLE I.—INCIDENCE OF THE MORE COMMON COMPLAINTS OF DYSPEPTICS BASED ON 3,000 HISTORIES

		Per cent
1.	Abdominal pain	47.7
2.	Constipation	46.5
3.	Flatulence	37.8
4.	Belching	33.6
5.	Headache	23.3
6.	Vomiting	19.9
7.	Epigastric Distress	13.8
8.	Abdominal Distention	12.7
9.	Heartburn	11.2
10.	Right Lower Quadrant Pain (in 1,691 x-rayed cases)	9.5
11.	Nausea	9.1
12.	Diarrhea	8.6
13.	Food Restriction	7.8
14.	Anorexia	6.0
15.	Regurgitation	3.9
16.	Globus Hystericus	3.2
17.	Vertigo	3.1
18.	Jaundice	3.1
19.	Bleeding (Hematemesis 38, melena 30)	2.3
20.	Bleeding (Bright blood in stools)	2.3

[1] Read before the Fourth International Congress of Radiology, Zürich, July 28, 1934.

toms do not occur unless this compensatory mechanism breaks down, a break which may result from any of the following causes:

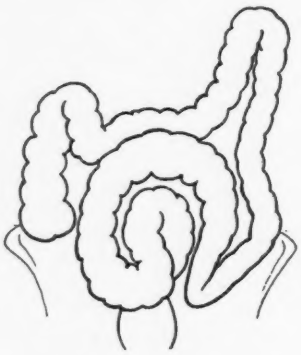


Fig. 1. Redundant colon: Large central pelvic loop, rising well above inter-iliac crest level (basic criterion).

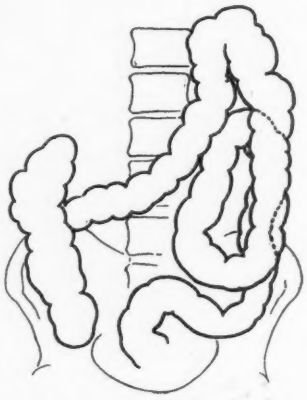


Fig. 2. Redundant colon: Complete loop of iliac portion.

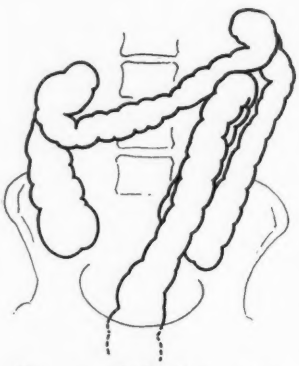


Fig. 3. Redundant colon: Double splenic flexure with straight efferent loop.

(*a*) Mechanical factors, such as strangulation of a silent Meckel's diverticulum.

(*b*) Infection, which may change a diverticulosis into a diverticulitis.

(*c*) Juxtaposition of two or more anomalies, such as the presence of ectopic gastric mucosa in a Meckel's diverticulum, which may lead to hemorrhage or perforation.

(*d*) Old age and increasing asthenia especially prominent in the case of all hernias and herniations, in which the weak spots exist from birth but the fully developed condition occurs later in life.

(*e*) Associated functional instability. When neuroses and anomalies co-exist, the former furnishes the underlying functional instability—the break in compensation—and the anomaly furnishes the particular digestive symptomatology for the clinical picture.

4. Because of variations in the compensatory mechanism, the symptomatology of anomalies is not continuous or progressive as in ordinary diseases. Thus, anomalies may cause symptoms in some of their owners all of the time, and in all of their owners some of the time, but are under no obligation to cause symptoms in all of their owners all of the time. This is the chief single differential between an anomaly and an acquired lesion and is of great importance in appraising the practical significance of anomalies.

Anomalies of the colon will be discussed under the following headings:

Anomalies of length: Redundant colon.

Anomalies of rotation: Non-rotation.

Anomalies of descent: Hypodescent, hyperdescent.

Anomalies of fixation: Hypofixation, hyperfixation.

ANOMALIES OF LENGTH: REDUNDANT COLON (DOLICHOCOLON)

Description and Roentgen Appearance.—The redundant colon (dolichocolon) is one which is too long to fit into the body of its owner without undergoing reduplication. The distal colon is the part usually though not invariably affected, the most common variety being an enlarged sigmoid loop centrally placed and rising well out of the pelvis (Fig. 1). Redundancy of the iliac colon is also frequent (Fig. 2). Two subvarieties are encountered often enough to receive the descriptive terms "double splenic flexure with straight efferent loop" (Fig. 3) and "pelvic loop to the right" (Fig. 4). Kinks of the colon, presumably

due to bands or adhesions, are rather frequent. Of these, 166 cases were encountered in our series but have been excluded from the group of true redundant colons and are not here discussed. Hirschsprung's disease (not discussed in this paper) differs from the redundant colon by the presence of enormous dilatation of the affected loops in the former.

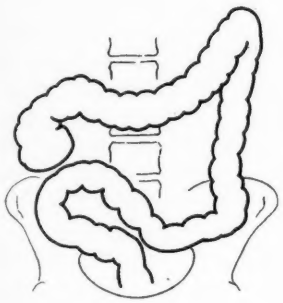


Fig. 4. Redundant colon: Pelvic loop to right.

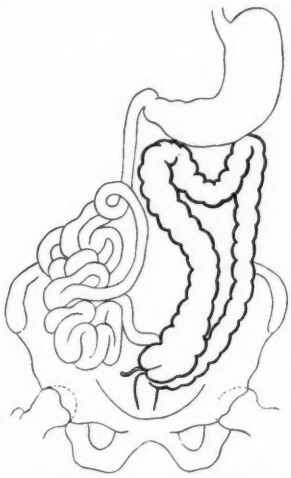


Fig. 5. Non-rotated colon: Showing ectopic small intestine with ileum entering colon from the right.

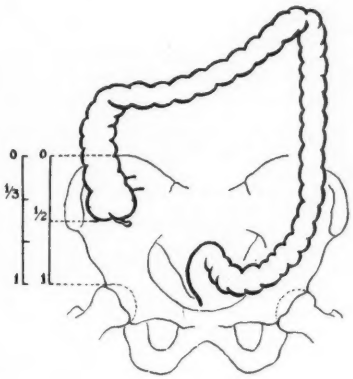


Fig. 6. Normal colon: Showing roentgen landmarks.

The diagnosis of redundant colon is made by roentgen examination after the opaque enema to show the form, and after the opaque meal to show the function, of the large intestine. The opaque enema is the basic procedure. Any case in which the enema-filled pelvic loop rises above a line joining the iliac crests is arbitrarily diagnosed redundant colon. Of course this criterion includes many mild and asymptomatic cases. The amount of enema fluid necessary to fill to the cecum averages 46 ounces (about 1,380 c.c.) in redundant colons and has reached as high as 120 ounces (about 3,600 c.c.). These figures are to be contrasted with the average 38 ounces (about 1,140 c.c.), required to fill the normal colon completely.

In many cases the stomach is displaced and deformed. The usual displacement is to the right and, since the cardiac end is fixed, the resulting appearance has been termed "cascade" stomach. In some cases the stomach is inverted or rotated on its horizontal axis so that it becomes retort-shaped.

Incidence.—In 1,850 roentgenographed patients, 343 cases of redundant colon were encountered, an incidence of 18.5 per cent. Analysis of this relatively large group shows that the anomaly affects both sexes (55 per cent females) and both extremes of habitus (29 per cent sthenics *vs.* 24 per cent asthenics) with approximately equal frequency. It is interesting to note, however, that the subvariety described as "pelvic loop to the right" occurs predominately in the sthenic habitus. Thus in 48 cases of this group there were 56 per cent sthenics, 44 per cent intermediates, and no asthenics.

Clinical Picture (*Table II*).—In the ten years since the publication of our first study in 1924, numerous observers (Larimore, White, Möller, Gauss, Bush, Strauss, Dagnino, Piccinino, and particularly Chiray, Lomon, and Wahl) have agreed that the redundant colon probably represents a definite entity with a constant incidence and clinical picture. Although, as with all anomalies, symptoms may be absent or variable, the combination of constipation, pain, and gas distress is characteristic.

TABLE II.—REDUNDANT COLON

Incidence	Per cent
General, in 1,850 roentgenographed patients	18
Sex:	
Females	55
Males	45
Habitus:	
Sthenics	29
Asthenics	24
Clinical Features	
Constipation (general incidence 46 per cent)	66
Distention, abdominal (general incidence 13 per cent)	21
Pain, abdominal (general incidence 47 per cent)	55
Pain, right lower quadrant (general incidence 9 per cent)	12
Tenderness right lower quadrant (general incidence 19 per cent)	27
Appendicitis, operation (general incidence 17 per cent)	22
Appendicitis, "pus" (incidence in appendicitis, operation 16 per cent)	15

The constipation, which is present in 66 per cent of cases (general incidence, 46 per cent), usually dates from birth. It is characterized by long intervals between stools (often one week) and by difficulty in expelling enemas, but is on the whole not associated with marked systemic or general upsets. Gas distress is often striking. It is most characteristic in the form of abdominal distention and occurred in 21 per cent of cases as against a general incidence of 13 per cent in our unse ected material. There is often localized distention corresponding to the redundant loop. Belching may represent a misdirected effort to relieve pressure in the splenic flexure, but this symptom occurred in only 21 per cent as against a general incidence of 34 per cent. The incidence of flatulence was the same as that in the unselected series (38 per cent).

Pain is present somewhere in the abdomen in 55 per cent of the cases (general incidence, 47 per cent). It is always due to superimposed spasm proximal to the point of redundance and may be associated with localized colitis, especially in patients who have acquired the cathartic or enema habit. The pains may suggest carcinoma or diverticulitis of the colon, heart disease, gall-bladder disease, or appendicitis. Pain in the right lower quadrant was present in 11 per cent (general incidence, 9 per cent), and tenderness in the right lower quadrant occurred in 27 per cent (general incidence, 19 per cent). Appendectomy was performed in 22 per cent as compared to a general incidence of 17 per cent in our basic 3,000 cases. Pus cases were, if anything, less frequent than in the general series.

Volvulus, although not encountered in this series, can occur only when the mesentery is elongated, as in redundant colon. It is our opinion, confirmed by the actual observations of several surgeons, that this accident usually follows violent efforts at purgation, resulting in irregular and atypical peristalsis.

Treatment.—The management of redundant colon consists essentially in the withdrawal of all forms of colonic abuse and the restoration of normal function by conservative procedures. The details of this therapy have been published elsewhere. The prognosis for relief is good. Surgical intervention should be reserved for cases of volvulus only.

ANOMALIES OF ROTATION: NON-ROTATION

Description and Roentgen Appearance.—Non-rotation of the colon represents an arrest of development whereby the cecum and succeeding portions of the colon remain in the left half of the abdomen and the coils of the jejuno-ileum in the right portion of this cavity. The condition may be complete or incomplete. When complete non-rotation exists, a mesenterium commune is invariably present.

Roentgenologically the cecum is found in the pelvis either in the mid-line or actually to the left. The ceco-colon ascends in the mid-line; the transverse colon is short, bent into an irregular shape, or may even be indistinguishable; the splenic flexure, and the colon distal to it, occupy the usual position. The entrance of the ileum into the ceco-colon is from the right instead of from the left side (Fig. 5).

Although this condition is generally assumed to remain fixed in adult life, this is not always true. In one of our cases which was carefully studied (both after opaque meal and opaque enema) the cecum and ceco-colon were found to be on the right

side at the 24-hour observation of the progress meal, although a complete non-rotation was present at observations made 4, 6, 8, 9, 10, 11, 48, and 72 hours after roentgenographed patients in whom the position of the cecum was carefully recorded—an incidence of 0.19 per cent. Two of our subjects were men, and two

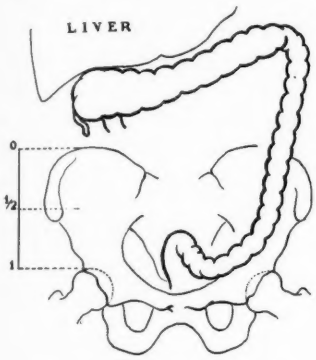


Fig. 7. High cecum: Subhepatic position (rare).

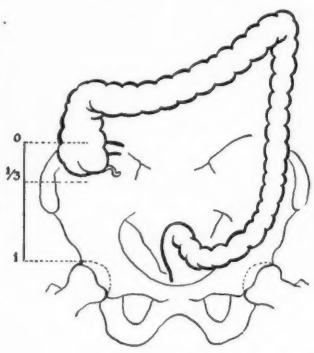


Fig. 8. High cecum: Common variety, showing roentgen landmarks.

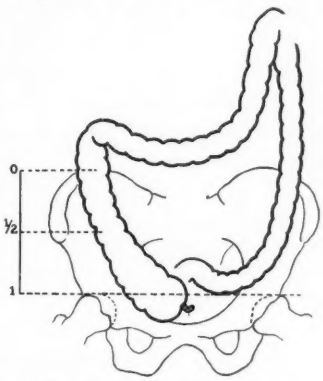


Fig. 9. Low cecum: Showing roentgen landmarks.

the opaque meal. The usual opaque enema revealed a complete non-rotation. Following the evacuation of the barium, a contrast enema (airgram) was made, a procedure which caused a complete rotation of the colon to the normal position. A second opaque enema was then administered and the normal condition was again demonstrated. However, subsequent examinations showed that the colon had reverted to its non-rotated arrangement.

In all of our subjects the entire small intestine was also non-rotated, the duodenum never crossing the mid-line. The converse situation, however, is not invariably true, since non-rotation of the duodenum may exist without non-rotation of the colon. There are two such cases in the present series. Incomplete non-rotation (partial rotation) of the cecum has been described. Such forms have not been positively demonstrated in our material.

The amount of opaque enema required to fill the colon averaged 35 ounces (about 1,050 c.c.). In other words, it was just short of the normal figure of 38 ounces (about 1,140 c.c.).

Incidence.—The condition is rare. Only four cases were encountered in 2,071 were women. In three, the habitus was described as intermediate, in the fourth it was asthenic.

Clinical Picture.—In a series so small as the present it is impossible to draw any general conclusions regarding the clinical significance of non-rotation of the colon. However, because of the relative rarity of the condition a brief tabulation of findings may be worth recording. All four were constipated; nausea occurred in three subjects, vomiting in two; three of the patients complained of headache; vertigo was recorded in two cases; no notation of this symptom was made in the other two; abdominal pain was noted in two subjects, but one of these was suffering from duodenal ulcer. Grave (surgical) accidents resulting from non-rotation seem to be rare; no instance was recorded in this series. However, such a possibility must be borne in mind whenever a mesenterium commune is present.

ANOMALIES OF DESCENT: HYPODESCENT (THE HIGH CECUM)

Description and Roentgen Appearance.—The cecum may be arrested in its embryologic descent at any stage between the liver and its normal resting place, which

is the middle of the right iliac fossa (Fig. 6). Since subhepatic ceca are rare (Fig. 7)—we encountered but 27 cases in which the cecum was at or above the iliac crest—we have included all ceca occupying the upper part of the iliac fossa in a group which we have arbitrarily designated "high cecum" (Fig. 8). The exact roentgen criteria delimiting this group are as follows:

1. In its highest position in any film of a given case, studied routinely by opaque meal and opaque enema, the tip of the cecum must appear above the iliac crest, at the crest, or in the upper third of the iliac fossa—as measured between the crest of the ilium and top of the acetabulum on the film taken in the usual prone position during slight inspiration.

2. In its lowest position in any film of the same given case, the tip of the cecum must lie within the upper half of the iliac fossa as above determined. A cecum that extended half-way down or more was excluded from the series.

3. The length of the ceco-colon as measured after the barium meal must not exceed 7 inches (17.5 cm.). This figure was chosen as the maximum for high ceca because (as shown in a previous study of this series) it represents the average length of the ceco-colon in normally placed ceca. These measurements are all obtained from films taken prone at a distance of 26 or 26.5 inches (65 or 66.3 cm.) from the tube target.

The diagnosis of high cecum is best made roentgenologically nine hours after the ingestion of an opaque meal. In some cases the cecum is attached to the liver, but the proximal transverse colon hangs down, festoon-like, in such fashion as to resemble a normal ascending segment. This may cause confusion unless observations are made in the right oblique position. Usually the right iliac fossa is occupied by loops of terminal ileum, but in some 5 per cent of cases the latter are replaced by a loop of pelvic colon. This arrangement has already been described as a subvariety of the redundant colon under the descriptive title "pelvic loop to the right." Its recognition is of some clinical importance because it may still further confuse surgeons in their attempt to locate the ectopic appendix in emergency operations in cases presenting high cecum.

Incidence.—In our series of 2,071 roentgenographed cases, high ceca were observed in 134 (6.5 per cent). Males predominated strikingly over females (76 per cent *vs.* 24 per cent), as did sthenics (74 per cent) over asthenics (4 per cent). High ceca are associated with hypofixation of the proximal colon (see below).

Clinical Picture (*Table III*).—On the whole, this group is composed of robust individuals remarkably free from the common manifestations of functional digestive upset. In this respect they offer a striking contrast to the group of patients with low cecum, next to be described. Using headaches and vomiting as typical expressions of functional digestive disorders, we find that the incidence of these complaints (18 per cent and 20 per cent, respectively) is about that in normal ceca (*i.e.*, in the general series) but is decidedly less than in low ceca.

TABLE III.—HIGH CECUM

Incidence	Per cent
General, in 2,071 roentgenographed patients	6
Sex:	
Males	76
Females	24
Habitus:	
Sthenics	74
Asthenics	4
Clinical Features	
Headaches (general incidence 23 per cent)	18
Vomiting (general incidence 20 per cent)	20
Constipation (general incidence 46 per cent)	36
Appendicitis, operation (general incidence 17 per cent)	23
Appendicitis, "pus" (incidence in appendicitis, operation 16 per cent)	26

Recalling the high incidence of constipation in redundant (long) colon, *viz.*, 66 per cent, it is interesting to observe that constipation occurs in but 36 per cent of cases of high cecum. Since this figure is also appreciably lower than the general incidence of constipation in non-selected cases, it would appear safe to make the generalization that constipation varies directly as colonic length.

The relation of high cecum to appendicitis is interesting. In the first place, the appendix being located at or near the liver instead of in the right iliac fossa, the clinical picture may resemble acute cholecystitis more than appendicitis. Furthermore, the presence of actual inflammation (pus appendix) is one and one-half times as likely (26 per cent) in high cecum as in the average appendectomy case (16 per cent), and more than two and one-half times more likely than in low cecum (10 per cent).

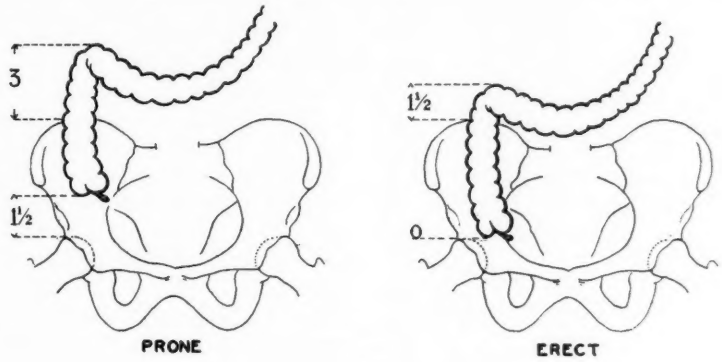


Fig. 10. Normal fixation of proximal colon: Showing range of mobility in prone and erect postures.

Treatment.—High cecum, as such, requires no treatment. One should take no chances with symptoms suggesting appendicitis and must be prepared to find the appendix high in the abdomen.

HYPERDESCENT (THE LOW CECUM)

Description and Roentgen Appearance.—The low cecum is the result of embryologic hyperdescent, the organ prolapsing below the right iliac fossa into the true pelvis. The anomaly furnishes a complete and striking contrast to the high cecum just described.

The diagnosis of low cecum is best made nine hours after the ingestion of the standard opaque meal. This anomaly may be said to exist when the cecal tip reaches down to or below the mid-pelvis, as determined by a horizontal line connecting the tops of both acetabular cavities on the standard prone film (Fig. 9). In accordance with our concept that the low cecum represents a true overgrowth rather than a local expression of ptosis, the length of the cecolon in these cases is increased from the average 7 inches (17.8 cm.) in the normal cecum, to an average of 9 inches (22.9 cm.), with the maximum reaching 13 inches (32.5 cm.). The cecal tip was fixed in 30 per cent of the cases; the rest of the cases showed a mobility of more than 1 inch (2.5 cm.). These figures are based on a review of all films (barium meal and enema) of a given case. If only the 9-hour prone and erect observations are considered, the incidence of fixation is higher (see below).

The most common associated anomaly was represented by duodenal bands, which occurred in 13 per cent of cases; *i.e.*, over twice the general incidence.

Incidence.—The low cecum ranks with redundant colon as one of the two most common anomalies of the colon. It was observed 379 times in our series of 2,071 roentgenographed patients, an incidence of 18.3 per cent. Women make up 74 per cent of the patients, and asthenics predominate over sthenics in the proportion of four to one (48 to 12 per cent). Low ceca are associated with hyperfixation of the proximal colon (see below).

TABLE IV.—LOW CECUM

Incidence	Per cent
General, in 2,071 roentgenographed patients	18
Sex:	
Females	74
Males	26
Habitus:	
Asthenics	48
Sthenics	12
Associated duodenal bands (general incidence 5 per cent)	13
Clinical Features	
Vomiting (general incidence 20 per cent)	41
Headaches (general incidence 23 per cent)	40
Pain, right lower quadrant (general incidence 9 per cent)	13
Tenderness, right lower quadrant (general incidence 19 per cent)	24
Appendicitis, operation (general incidence 17 per cent)	26
Appendicitis, "pus" (incidence in appendicitis, operation 16 per cent)	10

Clinical Picture (Table IV).—Low cecum is, we believe, responsible for a definite symptomatology. The complaints are of two orders, namely, general and local. The general symptoms are those ordinarily regarded as reflex or toxic in character. Chief among these are vomiting, which occurred in 41 per cent (general incidence, 20 per cent), and headache, which occurred in 40 per cent (general incidence, 23 per cent).

The vomiting in these cases is habitual and rather easy, being provoked by strain, fatigue, emotional excitement, dietary indiscretion, menstruation, and headaches. The patient may take this symptom so much for granted that she may fail to mention it in the history unless specifically questioned.

The headaches are often of the migraine type and are caused by the same factors as is the vomiting. Both these major manifestations may be represented by less severe symptoms. Thus, vomiting may be replaced by nausea, train or car sickness, and headaches by vertigo. These patients often exhibit other stigmas of physical, nervous, or emotional instability.

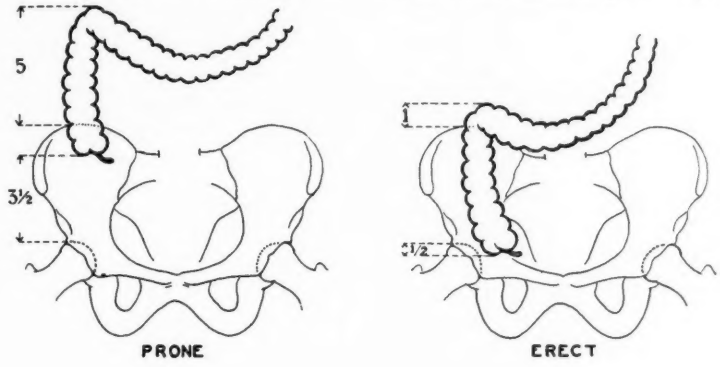
The local symptoms are referable to the right lower quadrant. Spontaneous pain in this region, which occurs in 9 per cent of all patients, is observed in 13 per cent of cases of low cecum. Tenderness in the right lower quadrant is also present more often (24 per cent) than in the general series (19 per cent). When cecal stasis is associated with low cecum, the figures for right-sided pain and tenderness increase from 13 and 24 per cent to 21 and 28 per cent, respectively. It is undoubtedly for this reason that patients with low cecum constitute the most frequently appendectomized group of colon anomalies (26 per cent *vs.* 17 per cent, general incidence). Appendix removal is obviously unwarranted in most cases because of the following reasons: (1) There is nothing in the history of low cecum on which a diagnosis of appendicitis can be properly based; (2) the observations at operation show the smallest proportion of pus cases of any group of colon anomalies that we have studied, namely, 10 per cent as against a general incidence of 16 per cent and an incidence in high cecum of 26 per cent.

Explanation of Symptoms.—In previous articles an explanation was offered for the symptoms encountered in cases of low cecum. As this explanation was largely theoretical, and particularly since it has not yet been confirmed or refuted by others, only the following summary will be presented here.

According to this hypothesis, the cause of the symptoms in low cecum may actually reside in the duodenum in which transient stasis is produced, no gross obstruction taking place. The transient retentions are assumed to result from the intermittent drag of the low cecum, the pressure being mediated through any of the structures that cross the second or third portion of the duodenum. These structures are the transverse mesocolon crossing the second portion, the right and middle colic artery, the superior mesenteric artery, and the root of the mesentery of the small intestine crossing the third portion. According to this view, the actual occurrence of symptoms would be favored by such features as the erect posture, stasis in the cecum, mesenterialization (hypofixation) of the ascending colon with increased mobility of the cecum, and the presence of duodenal bands. The latter adhesions would, by fixing the duodenum, tend to "step up"

the effect of colonic dragging so that subminimal stimuli might become effective.

Treatment.—The medical management of low cecum consists in treating the asthenic habitus, controlling the neurosis, fattening the patient, and relieving the cecal stasis, which may be accomplished by correcting the distal constipation when present, thus clearing the track ahead. In none of our cases was it found necessary to recommend surgical therapy.



HYPOFIXATION

Fig. 11. Hypofixation of proximal colon: Showing range of mobility in prone and erect postures.

ANOMALIES OF FIXATION

Description and Roentgen Appearance.—The process of fixation of the large intestine is normally completed by the sixth or seventh month of fetal life. Departures from the normal development may take place in either of the following two directions: (1) There may be an arrest in fixation with a persistence of the primitive mesentery and increased mobility (hypermobility, hypofixation) of the ascending colon, with or without a mesenterium commune, or (2) there may be an abnormal progression of the fixation process, resulting in excessive adhesion (hyperfixation, hypomobility). This excess of fixation may involve the whole course of the ascending colon, or only certain portions of it. Similar abnormalities may affect the distal colon but they are more difficult to study and will not be considered in this communication.

Much has been written about the clinical (especially the surgical) significance of both hypofixation and hyperfixation without a sound knowledge of important basic data concerning colonic fixation. A study of this subject correlating essential clinical and roentgen data in 383 cases has recently been published by the writer. In that communication detailed statistics are presented relating to the fixation of the hepatic flexure alone, the cecum alone, and the ceco-colon as a whole. The following paragraphs represent a summary of this investigation.

Roentgen Technic and Criteria.—Fixation of the ascending colon is best studied nine hours after the administration of an opaque meal. Films are made in both erect and prone positions (Fig. 10). The location of the hepatic flexure is noted in relation to the crest of the right ilium in each position. Similarly, the location of the tip of the cecum is noted in relation to the top of the right acetabulum.

The average range of mobility of the hepatic flexure in the shift from the prone to the erect posture is one and two-thirds inches (4.2 cm.): the average vertical mobility of the cecum is about one and one-third inches (3.4 cm.). For the purpose of this study, excessive mobility of the hepatic flexure was arbitrarily diagnosed when the vertical excursion reached 3 inches (7.4 cm.) or more. Ex-

cessive mobility of the cecum was diagnosed when the excursion reached two and one-half inches (6.4 cm.) or more. Excessive fixation of either the hepatic flexure or the cecum was arbitrarily assumed to exist when the vertical range in mobility resulting from change in posture was 1 inch (2.5 cm.) or less.

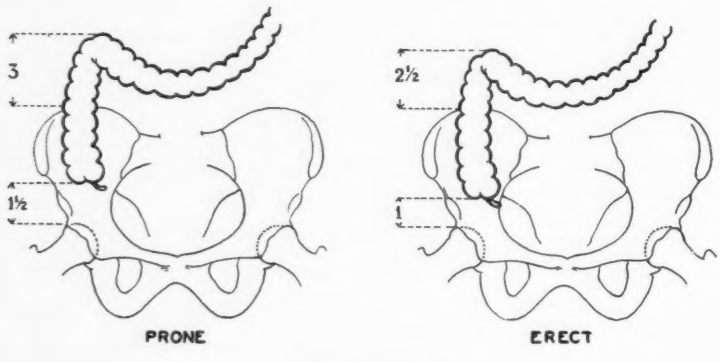


Fig. 12. Hyperfixation of proximal colon: Showing range of mobility in prone and erect postures.

HYPOFIXATION (EXCESSIVE MOBILITY)

Incidence.—Hypofixation of either the hepatic flexure or the cecum occurred in 10 per cent of the 383 cases studied in this series. Hypofixation of the ceco-colon as a whole occurred in 4 per cent of the cases. Excessive mobility in general is associated with the sthenic habitus and with a high cecum (Fig. 11, Table V).

Clinical Picture.—Hypermobility of the hepatic flexure alone is associated with right lower quadrant pain (25 per cent *vs.* general incidence of 9 per cent) and with right lower quadrant tenderness (27 per cent *vs.* general incidence of 19 per cent). There is also an association, though less striking, with colonic stasis.

Hypermobility of the cecum alone is associated with increased colonic irritability. Hypermobility of the entire ceco-colon, with or without a mesenterium commune, is a prerequisite for such acute surgical complications as volvulus of the ceco-colon, ileo-cecal intussusception, and prolapse of the cecum through a hernia. In Wandel's classic case of mesenterium commune, the duodenum and mesenteric pedicle were completely encircled and strangulated by the absolutely unattached proximal colon. (As has already been mentioned, cases of non-rotation of the cecum are of necessity also cases of mesenterium commune.) Finally, it may be mentioned that none of our 19 mobile ceco-colon cases developed any of the acute surgical complications above mentioned.

HYPERFIXATION (EXCESSIVE FIXATION)

Incidence.—Hyperfixation of the hepatic flexure occurred in 28 per cent of the cases; of the cecum in 43 per cent of the cases, and of the ceco-colon in 20 per cent of the cases. As already mentioned under "low cecum," if all the films of a given case are considered, the figures for the cecum (and perhaps for the rest of the ceco-colon in proportion) will be found to drop to 30 per cent. Excessive fixation, in general, is associated with low ceca and with duodenal bands (Fig. 12, Table VI).

Clinical Picture.—Hyperfixation of the hepatic flexure alone is associated with a moderate tendency to colonic irritability. Contrary to the common opinion, there is no evidence of association with gall-bladder disease, nor does cholecystectomy

tend to fix the hepatic flexure. In other words, in the majority of instances the fixation represents a congenital, not an acquired, phenomenon.

Hyperfixation of the cecum alone, when the organ is not low placed, is apparently asymptomatic. There is no evidence that cecal fixation results from appendectomy. Hyperfixation of the entire ceco-colon is associated with increased colonic irritability.

Therapy.—Variations in fixation of the ceco-colon as a whole, or of either of its terminations (cecum, hepatic flexure) do not seem to be responsible for any marked clinical disturbances. The symptoms encountered resemble those commonly associated with the unstable colon and respond reasonably well to conservative medical management. In none of the cases reported in this study was it found necessary to recommend surgical therapy. This should be restricted to cases in which intestinal obstruction is demonstrated.

SUMMARY

This study is based on a series of approximately 2,000 consecutive cases in which the colon form and function was observed roentgenologically. This series, in turn, constitutes a part of a basic group of approximately 4,000 private patients complaining of various digestive symptoms, thus furnishing a homogeneous background for the conclusions here presented.

Anomalies of the colon are discussed under the following headings:

Anomalies of length: Redundant colon.

Anomalies of rotation: Non-rotation.

TABLE V.—HYPOFIXATION OF PROXIMAL COLON

	Hepatic Flexure (40 cases)	Cecum (40 cases)	Ceco-colon (15 cases)	General Incidence
	Incidence (Per cent)			
General, in 383 roentgenographed patients	10	10	4	
Habitus				
Asthenic	10	8	7	21
Sthenic	47	55	60	29
Associated Anomalies				
High Cecum	15	30	27	6
Low Cecum	13	3	0	18
Duodenal Bands	8	8	13	5
	Clinical Features (Per cent)			
Right Lower Quadrant Pain	25	10	20	9
Right Lower Quadrant Tenderness	28	18	13	19
Constipation	58	33	47	47
"Colitis" (Irritable Colon)	58	73	73	57
Gall-bladder Disease	13	13	20	6

TABLE VI.—HYPERFIXATION OF PROXIMAL COLON

	Hepatic Flexure (107 cases)	Cecum (166 cases)	Ceco-colon (76 cases)	General Incidence
	Incidence (Per cent)			
General, in 383 roentgenographed patients	28	43	20	
Habitus				
Asthenic	19	31	24	21
Sthenic	32	28	29	29
Associated Anomalies				
High Cecum	3	4	5	6
Low Cecum	26	39	37	18
Duodenal Bands	10	11	11	5
	Clinical Features (Per cent)			
Right Lower Quadrant Pain	8	13	15	9
Right Lower Quadrant Tenderness	16	22	18	19
Constipation	45	46	42	47
"Colitis" (Irritable Colon)	67	56	64	57
Gall-bladder Disease	3	5	4	6

Anomalies of descent: Hypodescent, hyperdescent.

Anomalies of fixation: Hypofixation, hyperfixation.

The redundant colon (dolichocolon) was present in 18 per cent of cases. Its chief clinical aspects are its occurrence in all builds and both sexes, and its association with marked constipation, and, less often, with pain and gas.

Non-rotation of the colon is rare. It was present in about 0.2 per cent of cases. It is often a manifestation of non-rotation of the entire intestinal tract in which case it is associated with mesenterium commune. In the majority of cases the condition seems to be asymptomatic.

High cecum (hypodescent of the cecum) occurred in 6 per cent of cases. Its chief clinical aspects are its occurrence in eupeptic, sthenic males, and the ectopic position and increased tendency to inflammation of the appendix.

Low cecum (hyperdescent of the cecum) occurred in 18 per cent of cases. Its chief clinical aspects are its occurrence in asthenic women and its association with headaches and vomiting, and discomfort in the right lower quadrant.

Hypofixation (excessive mobility) of the proximal (ceco-) colon occurred in 4 per cent of cases. It is associated with the sthenic habitus and high cecum, and is a prerequisite for volvulus and intussusception. Hypofixation of the hepatic flexure alone is associated with right lower quadrant pain and tenderness. Hypofixation of the cecum alone is associated with increased colonic irritability.

Hyperfixation (excessive fixation) of the proximal (ceco-) colon occurred in 20 per cent of cases. It is associated with low ceca, duodenal bands, and colonic irritability. Hyperfixation of the hepatic flexure alone is associated with colonic irritability. Hyperfixation of the cecum alone is apparently asymptomatic.

Surgical therapy is not indicated in the great majority of colon anomalies: this form of treatment should be reserved for instances of actual intestinal obstruction. In most cases a conservative plan of management, based on the restoration of normal colon function, suffices for the relief of symptoms.

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SOURCES OF ERROR IN ORAL CHOLECYSTOGRAPHY, WITH SUGGESTED METHODS OF CORRECTION[1]

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A SATISFACTORY oral Graham series requires more attention to detail than any other type of x-ray examination. To overlook any one of many essentials in performing the test may ruin the entire examination. While certain standardization is helpful, there must be variation in technic if the full value of the method is utilized.

There are certain errors in cholecystography which are due, *first*, to the patient, *second*, to the technic, and—last and most important—due to misinterpretation. These will be dealt with in their order and an effort made to outline corrections.

First, Errors Due to the Patient.—An individual may be unable to co-operate fully on account of illness, or he may misunderstand the instructions so that he does not do as directed.

Completely suspending respiration is very difficult for some patients, especially should they be suffering from cardiac lesions or ascites. Much can be gained by taking sufficient time properly to instruct the patient before any films are exposed. It is surprising to note how many individuals are unable to comprehend simple instructions and fail repeatedly in carrying them out. Holding the nose during suspension of respiration is often of great assistance. Comparison of a number of films of the same patient made at the same time will always show some of greater brilliance of detail than others and these films invariably are those made while the patient suspended respiration most satisfactorily.

There may be inadequate preparation of the patient because of "gas" pockets in the hepatic flexure or stomach or even retained intestinal contents. Incompletely absorbed dye may also interfere with clear visualization of the gall-bladder region. It is essential that a *cleansing enema* be given immediately before the examination in cases in which the gall bladder is to be outlined with maximum intensity so that the bowel may be clear of confusing, overlying shadows.

The patient may have been given something to eat during the fasting period due to a misunderstanding of orders and the gall bladder may be partially emptied of its opaque bile as a result of this lack of co-operation.

Second, Errors Due to Imperfect Technic.—Many errors may creep into the technic of performance of the oral Graham test. Let us consider those concerning the tetraiodo first.

It is essential that the dye be stored in amber glass ampoules or air-tight containers so that no oxidation or other chemical changes may occur before the patient receives it. The authors have found that the most satisfactory method of administering the dye is to dissolve it in a glass of water seasoned with a little fruit syrup.

TECHNIC OF THE INTENSIFIED METHOD

Using oral cholecystography as a means for investigating the emptying power of the gall bladder following the administration of cholegogues, we noted that in cases in which starvation was continued and the dye repeated the gall-bladder shadow was markedly intensified (1). We supplemented these findings with certain research developments of Antonucci (2) and Sandstrom (3), the former having demonstrated that oral cholecystography may be accelerated by adding to the glucose reserve of the body, and the latter having found that

[1] Read before the Fourth International Congress of Radiology at Zurich, Switzerland, July, 1934.

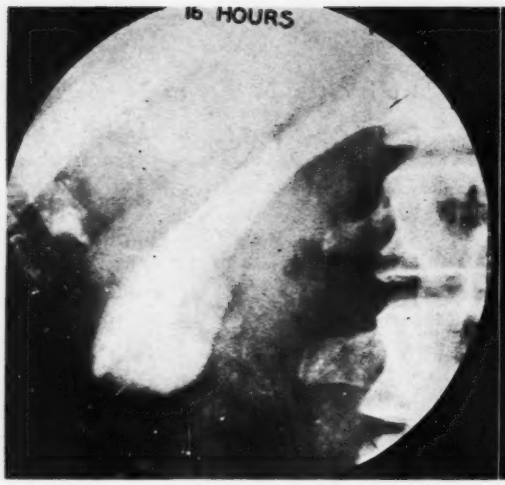

Fig. 1. Case *A*. Oral cholecystography. Film taken 16 hours after tetraiodo. A faint shadow (by old technic).

Fig. 2. Case *A*. Forty hours after intensified technic. The advantages of the new method can be readily appreciated. This is no longer a "faint shadow" case.

giving the dye in fractional doses increased the shadow. The authors have devised the following new technic for what they claim is the "intensified method of oral cholecystography, the details of which follow."

The afternoon preceding the Graham test the patient is given two or three cups of weak tea with as much sugar as possible, accompanied by one sweet cake.

The tetraiodo (3.5 grams) is given directly after the evening meal, at about 7 P.M. No extra fats are ordered at this meal as they generally cause increased discomfort and are not necessary.

Starvation is ordered for the following morning and its importance explained to the patient. Study of the gall bladder is undertaken sixteen hours after administration of the dye, to estimate the mucosal function of concentration. With the new intensified technic there has been a tendency to drop the 12-hour examination as unnecessary or needless. Selected foods are then allowed which will not empty the gall bladder, *extra sugar* being one of the important items. Additional dye is given in small doses during the afternoon and evening, along with more sugar. An examination of the gall bladder for maximum concentration and intensity of the shadow is then made before breakfast the following morning, forty hours after the first dose of tetraiodo. Then a fatty meal is taken and an hour later study is made of the function of contractability as the viscus empties. Tumors and stones often come to light as the gall bladder empties. Sometimes the patient has to be kept under observation for a number of hours as emptying progresses.

This modified technic has certain definite advantages to compensate for the additional time and limited intake—to which most gall-bladder patients do not object to anyway. There is *less* nausea and discomfort complained of by the patient with this new method.

There is far more uniformity to the normal intense shadow obtained at the 40-hour observation, whereas many normal cases varied considerably in the shadow density at the 16-hour with the old technic.

It is far easier to determine when a shadow is *faint*. The intensified method either gives a shadow or not, and the *faint shadow is more rare* than with the former technic (Figs. 1 and 2).

Stones and tumors of the gall bladder are more easily recognized; faint shadows

Fig. 3. Case *B*. Sixteen hours after tetraiodo; film taken by old technic.

Fig. 4. Case *B*. Note increase in density in normally functioning gall bladder, with "intensified technic."

of cholesterin stones are visualized more readily (Fig. 10).

The bile ducts are clearly outlined in practically every case in which a normal gall-bladder shadow intensity is obtained.

A gall bladder over the spine, which was formerly easy to miss and report as a "no shadow," is now more easily detected.

Fluoroscopy of the gall bladder is practical on any case in which a gall-bladder shadow is obtained.

There are certain *roentgenographic improvements* which aid in obtaining these better roentgenograms.

A fast Bucky is now used which permits exposures up to one-twentieth of a second. With such fast technic, fuzziness of the gall-bladder shadow due to motion is lessened, if not entirely overcome. The contrast obtainable is extreme and the visualization of small calculi is rendered more exact.

Compression is an advantage when the patient will permit it. It is amazing how much difference in the quality of roentgenograms results when the patient is thoroughly compressed and the abdominal organs are immobilized.

We use a standard technic of 100 ma. and one-half second time, with less time in certain cases. A fine focus tube may be used at this milliamperage and the general quality of the work is excellent. The results obtained from a Graham test satisfactorily performed may be grouped in five main classes:

(*A*) The gall bladder is visualized.
(*B*) The gall bladder is faintly visualized.
(*C*) The gall bladder fails properly to empty.
(*D*) There is no distinguishable gall-bladder shadow.
(*E*) Gallstones are present.

With any of these findings, one may make certain mistakes of interpretation.

(*A*) When a gall-bladder shadow is outlined with fair intensity, the inclination of the interpretor is to regard the viscus as normal in function and, therefore, not diseased. Such a statement may be incorrect, as patients recovering from a recent attack of acute cholecystitis have been repeatedly examined and an excellent shadow obtained. The organ recovers from an acute disease and the mucosal function is regained sufficiently to result in normal shadow concentration.

Adhesions may result following an acute

Fig. 5. Case *C*. Film taken 40 hours after first dose of tetraiodo; intensified technic. Note that the beautiful gall-bladder outline is as dense as the barium-filled stomach. Good function.

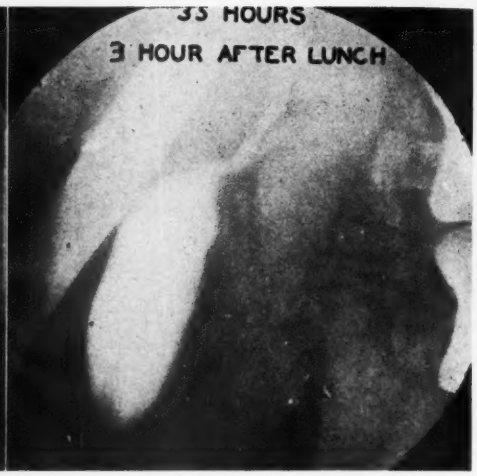

Fig. 6. Case *C*. New technic; film taken three hours after lunch. Note slow emptying, with detail of ducts.

attack of cholecystitis, so that the viscus may be literally coated or sheathed in them. The Graham test may demonstrate a normal gall-bladder shadow of good intensity and not deformed. The fact that the viscus is held constantly in an unusual position, whether the patient is erect, supine, or prone, usually indicates adhesions, and fluoroscopy may aid in detecting lessened mobility and tenderness. Further study of the gall bladder as it contracts down after an emptying meal may aid. In some cases we have resorted to pneumoperitoneum to actually demonstrate the adhesional bands.

The long pendulous gall bladder may appear deformed on some films or even maintain a fixed abnormality which disappears when the patient is examined in the erect position (Figs. 7 and 8).

If the gall bladder functions normally so that a shadow is obtained of average intensity and the viscus contracts down well after a meal, any adhesions which are present are scars of previous disease and not necessarily causing the present complaints. We have heard one surgeon volunteer the statement that he has stopped operating on gall bladders with visible shadows on a Graham test because he has found by experience that, when he does, the patients return later on with no improvement of symptoms.

(*B*) *Faint Shadow.*—It is in the recognition of this condition that the roentgenographic diagnosis of cholecystitis is most often overlooked.

The authors have frequently been asked, "Just what do you consider a faint shadow?" We have to confess that there is a certain human element involved that cannot be described with unfailing exactitude. One man may consider a shadow faint while another is satisfied that it is within normal limits.

All this applies to the old technic. With the intensified method of cholecystography, one can be much more definite and immediately recognize a shadow that is faint. It is learned by experience, however, and not by any shadow index. The pathology that gives a faint shadow finding is most often located in the mucosa, producing a lack of proper concentration.

(*C*) *Defective Emptying.*—We believe, as many observers before us have reported, that when the gall bladder fails to completely empty within three hours after a fatty meal, it is pathologic and that this lack of proper emptying is due to a lesion

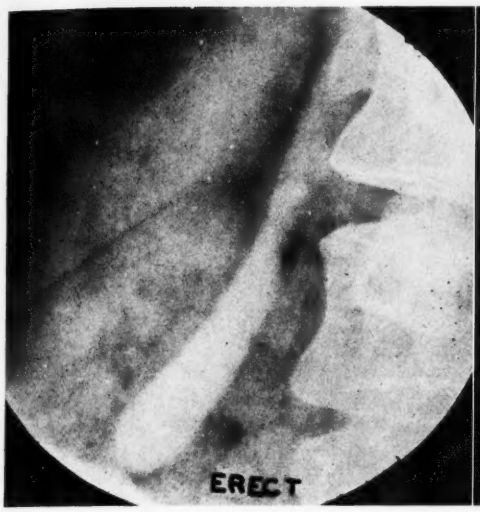

Fig. 7. Case *D*. Note elongated gall bladder in erect position with intensified technic.

Fig. 8. Case *D*. Note deformity of gall bladder produced by position. No adhesions.

involving the muscular coat. In our experience there is only one non-pathologic condition which will produce delayed emptying and that is asthenia. These cases are rare, but occasionally individuals of this type will present themselves and their gall bladders will not completely empty for twenty-four hours and sometimes longer.

(*D*) *No Shadow.*—These findings are of increased importance when resulting at forty hours with this technic, and hardly need checking or further confirmation unless there is reason to suspect error that can be corrected.

There is a high average of obstructed cystic ducts as a cause for this finding of "no shadow" and many times calcified stones are distinguishable as direct proof of this etiology. The region of the lateral border of the spine should be carefully searched for the ring-like shadow of a gallstone in the cystic duct in all "no shadow" cases.

One should always be certain before making his report that the gall bladder has not been removed by previous operative procedure. Also there should be a definite, authorative statement as to the presence or absence of jaundice. Inquiry should be made as to whether the patient had diarrhea or vomiting following the dye and whether anything was eaten that should not have been. All these conditions tend to prevent satisfactory results from cholecystography.

The "no shadow" finding makes it necessary to be certain that the technic is not faulty. Films of a Graham series without a perceptible shadow are the ones brought in most frequently from outside laboratories by anxious physicians who desire to know if the patient should be operated upon. To judge such films, whether satisfactory or not, certain rules must be kept in mind:

(1) Is there dye present in the intestines and visible on the films so that we know that the patient received the test and that it was not lost by vomiting or diarrhea?

(2) The lower edge of the liver shadow and the right kidney must be clearly outlined as well as that of the psoas muscle. Status inversus must be excluded.

(3) The bony trabeculæ of the ribs and spine must be sharply outlined.

(4) The examination must include the pelvis if the patient is thin. If the re-

Fig. 9. Case *E*. Note faint gall-bladder shadow, with constriction: large non-opaque stone in lower segment. Old technic.

Fig. 10. Case *E*. Intensified technic: film taken 40 hours after first dose of tetraiodo. Note increased detail to constricted gall-bladder shadow, with stone.

verse, the lateral chest and abdominal wall should be included so that the gall bladder is within the area examined.

(5) Study of the spine must be made to be certain that the gall bladder is not hidden by the bony structure.

(6) At least three satisfactory films must be available covering each examination period.

In cases of duodenal ulcer, a "no shadow" finding sometimes results. With this technic it is advisable to consider that two lesions are present, a duodenal ulcer and a diseased gall bladder. We have had numerous cases of duodenal ulcer with normal gall-bladder shadows.

Renal tumors, when extensive, may give a "no shadow" finding and the gall bladder be found apparently normal at operation.

Regardless of the cause of the jaundice, the oral Graham test fails to outline the gall bladder *satisfactorily* if the ichteric index is over 30. This corresponds to an ichterus which is barely tinting the skin in a good light. Just why the bile is not opaque in the presence of jaundice is difficult to understand. Investigations are now under way which attempt to supply the deficiency in glycogen in the liver which is present in varying degrees in jaundice, by giving the patient increased quantities of sugar. In some cases we have been able to render the bile opaque, although the shadow obtained of the gall bladder was faint.

(*E*) *Gallstones*.—Gallstones are of two types in their roentgenographic manifestations, calcified and non-calcified, or cholesterin, stones.

If there is sufficient calcium content, the calculi are discernible without the Graham test; this is true in about one-third of the cases. There is quite a large group of patients with gallstones of such low calcium content that they are invisible except on roentgenograms of the highest technical quality.

Non-calcified stones are preceptible only when a gall-bladder shadow is present. If the cystic duct is obstructed, the tetraiodo cannot enter the gall bladder and no shadow of the viscus will result. The gall bladder may be filled with cholesterin gallstones but they will be invisible as long as the gall bladder is not outlined with opaque bile. This is the confusing "no shadow" case without visualization of the

Fig. 11. Case F. Film taken at 16 hours old technic. A faint shadow with indefinite mottling from multiple small calculi.

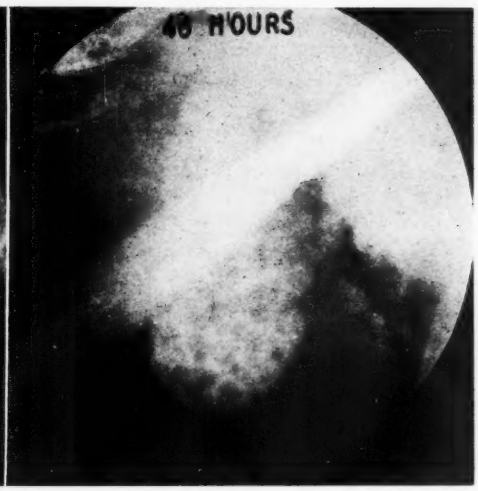

Fig. 12. Case F. Film taken at 40 hours intensified technic. The pathology is clearly demonstrated due to the increased detail.

gall bladder or stones; the clinical findings may be indefinite as well. It is this type of case which requires flawless, exacting attention to every detail of the roentgenographic technic, or mistakes will surely be made.

Small *cholesterin stones* and sometimes a large solitary calculus may give a confusing shadow, barely perceptible even on films of excellent technical quality, and difficult to differentiate from gas bubbles and intestinal content. There are certain shadows from stomach and intestinal content which can be differentiated from gallstones only by repeated examinations or special maneuvers. A cleansing enema and an immediate re-examination, the drinking of half a glass of hot water, massage of the abdomen, or a short walk are measures which may solve the difficulty. Repeating the test is the final and most efficacious attempt toward success in the correct interpretation. A dozen pinhead-size cholesterin gallstones and even a single large stone or an adenoma or papilloma of the gall bladder may be overlooked unless the shadow intensity of the viscus is satisfactory. Unfortunately, the lesion may cause a faint shadow, with the result that the small stones are not detected. This is another reason why the utmost shadow opacity of the gall bladder is desirable and why the *intensified technic* is more efficient. The study of the emptying of the gall bladder usually aids in defining the lesion.

Differentiation of extrinsic shadows likely to be mistaken for stones include the following:

Gas in the Duodenum.—Bubbles of gas in the small intestines and pyloric region may directly overlie the gall bladder and cause confusing shadows easily mistaken for non-calcified stones. As a rule, shadows of gas bubbles shift in position on various films sufficiently so that their lack of the same shape, size, and constant position differentiate them. Taking a glass of hot water, several deep breaths, or a walk before another film may displace them. Gas bubbles have a sharper margin and the blackness of the gas is greater than non-calcified stones, whose borders are less sharply defined and whose central portion is gray rather than black. Non-calcified stones may be single or multiple, and, if multiple, the edge of the shadow may tend to be facetted. When multiple, the shadows of the stones are generally much the same size and uniform in appearance,

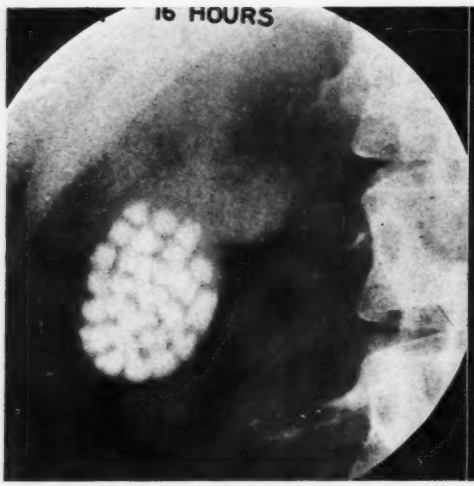

Fig. 13. Case *F.* Note gall-bladder shadow in the presence of calcified gallstones. Old technic; film taken 16 hours after tetraiodo.

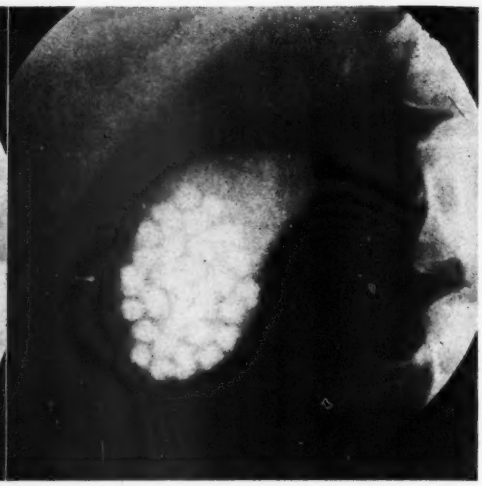

Fig. 14. Case *F.* Note concentration of gall bladder even in the presence of numerous stones: cystic duct patent. This film was taken 40 hours after first dose of tetraiodo. New technic.

whereas gas has bizarre shapes—no two alike. The film after the emptying meal forces the stones together and the general bunching of the stones within the gall-bladder shadow is quite characteristic. Study of the contracting gall bladder is prolonged in the intensified method and this is an added advantage of the new technic.

Calcified mesenteric glands have the following characteristics: The shadows are mottled like the mottled surface of a loganberry or raspberry; they may be a cluster of round dots. The calcified shadow is usually irregular, seldom faceted. Each mass of glands may make up one spherical whole. These glands are generally multiple shadows but widely separated—too far to be within the gall bladder. On various films the same gland may have widely different positions, indicating much greater range of motion than gallstones could have. This is especially marked if some films are taken with the patient standing or supine for comparison with the usual prone films. Occasionally typical calcified gland shadows prove to be stones in the cystic duct.

Urinary calculi are often found on gall-bladder examinations and the character of the calcified shadow is characteristic. Branching, hornlike, half-moon-shaped renal calculi or casts of the renal pelvis are easy enough, but certain ureteral stones in the upper end of the right ureter may cast faceted shadows which are more difficult to differentiate. The *lateral* view is always an aid in further eliminating suspicious shadows, as it places the calcification within the gall-bladder area—well to the anterior.

Visualization of Ducts.—The cystic duct is most commonly visible but hepatic and common ducts are distinguishable on some of the roentgenograms and any of the ducts may be demonstrated if one wishes to follow along for a sufficient time, provided, of course, that the gall bladder has normal shadow intensity. The best time to outline the ducts is following the meal, as the gall bladder contracts down and empties. Heister's valves are often strikingly shown.

Following operative removal of the gall bladder the patient may have a return of symptoms, whereupon the doctor may refer him for a Graham, fearing that new stones have formed in the ducts. There is occasionally sufficient dilatation of the ducts by a stone to make it seem as though a new

small gall bladder has reformed. We had a case in which two small cholesterin stones were demonstrated within the dilated remains of a cystic duct after cholecystectomy. The opaque bile outline the two stones like the eyes of an owl. The case was operated upon and the findings were confirmed.

Kirklin (4) was the first to recognize tumors of the gall bladder and to differentiate them from stones. He maintains, and we support his conclusions, that benign growths, especially papillomas, are more likely to be seen along the margin of the gall-bladder shadow or in the midsection of the fundus—seldom in the lower portion. The shadow defect is usually round, small in size, and maintains the same relative position on all the roentgenograms. At times these defects may be multiple; if so, they are never aggregate but more likely discrete, in contradistinction to gallstones. Many times these negative areas do not appear until the gall bladder has partially emptied. It is possible that they really have very little clinical significance, as most cases giving a definite defect show an intense gall-bladder shadow.

Adenomas give somewhat different findings from papillomas—the defect is nearly always at the tip of the fundus and is more likely to be slit-like in character rather than round. It varies in size but is persistent in location. In adenomas the gall-bladder shadow is more likely to be somewhat faint, showing more pathologic changes in the walls, and is more frequently found as the gall bladder empties.

SUMMARY

(1) A new oral method of intensified cholecystography is presented based on fractional doses over a longer period of time, a fast Bucky, and the administration of glucose before and during examination.

(2) Consideration is made of certain errors due to the patient, and the roentgen technic is recounted in detail.

(3) Some easily misunderstood problems in interpretation are considered, such as "faint" and "no shadow" cases.

(4) A differential diagnosis has been compiled covering confusing intrinsic and extrinsic shadows, with remarks emphasizing the characteristics brought out by Kirklin on papilloma and adenoma of the gall bladder.

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THE VALUE OF ENCEPHALOGRAPHY AS A DIAGNOSTIC AND THERAPEUTIC AGENT

By WALTER D. ABBOTT, M.D., F.A.C.S., *Des Moines, Iowa*

THE procedure of encephalography as a diagnostic and therapeutic agent has become more popular in the past few years. As in all new ventures in medicine and surgery, extravagant claims have been made for the relative merits for this addition to our armamentarium.

There is no question but that encephalography has been of distinct advantage in certain conditions and guilty of providing misleading or worthless clues in pursuing the cause of other disease entities: Thus, it is the purpose of this paper to present a critical review of a series of cases, taken in consecutive order, and to discuss the relative merits of encephalography in each individual instance.

It seems unnecessary to repeat the history of the development of this procedure, with its gradual evolution into the present technic, which is practically standardized. Thus, each type of disease condition in which the following cases have been applied will be briefly discussed.

Brain Tumors.—There are certain instances in which the presence of an intracranial growth is suspected, with a paucity of localizing signs. No case of suspected brain tumor should be submitted to a mechanical means of diagnosis until every neurologic, opthalmologic, and roentgenographic clue has been carefully investigated. There are, however, instances in which further efforts are indicated so that a proper diagnosis and localization can be made. It has been emphasized repeatedly that encephalography is dangerous in the presence of increased intracranial pressure as evidenced by choked discs and a high spinal manometric reading. Thus, en-

TABLE I

Clinical Diagnosis	Roentgenograms	Encephalographic Studies	Diagnostic Value	Therapeutic Value and Comments
1. Tumor suspected; not localized	Negative	Tumor right parietal lobe	Positive	Inoperable glioma of right temporal lobe
2. Tumor suspected; not localized	Negative	Filling defect posterior horn of right lateral ventricle	Misleading	None. Exploration; no tumor found; autopsy, meningoependymitis
3. Tumor suspected; not localized	Negative	Tumor right parietal lobe	Positive	Inoperable glioma (spongio-blastoma multiforme) right parietal lobe
4. Tumor suspected; not localized	Negative	Tumor right temporal lobe	Positive	Exploration. Aneurysmal varix right temporal lobe
5. Tumor suspected; not localized	Negative	Filling defect right lateral ventricle	Misleading	Exploration; no tumor found
6. Tumor suspected; not localized	Negative	Tumor left parietal lobe	Positive	Exploration; subcortical cyst
7. Tumor suspected; not localized	Increased intracranial pressure	Tumor right temporal lobe	Positive	Inoperable glioma (spongio-blastoma multiforme) right temporal lobe
8. Tumor suspected; not localized	Increased intracranial pressure	Filling defect third and right lateral ventricles	None	Ventriculography necessary. Third ventricle tumor
9. Tumor suspected; not localized	Negative	Filling defect of third ventricle	Positive	Third ventricle tumor. Autopsy
10. Tumor suspected; not localized	Increased intracranial pressure	Tumor left frontal lobe	Positive	Exploration. Inoperable glioma left frontal and temporal lobes (spongio - blastoma unipolare)

cephalography is of value in cases of suspected tumor in which the signs of pressure are absent. It is necessary, however, at times to supplement ventriculography when the encephalographic findings are not conclusive, as stressed by Dandy and illustrated in three of the following cases.

Adson presented an excellent evaluation of this procedure in 1931 and I am taking the liberty to borrow his means of critical analysis.

The above ten cases had variable signs and points in each history which would lead to a suspicion of brain tumor. In no case was there presence of choked discs or an increase of spinal fluid pressure above 20 cm. of water. Eight of the ten cases were explored and in six the encephalograms were found to have been of definite localizing value. In two instances (Cases 2 and 5) the localization was definitely misleading as no tumor was found. There was one instance (Case 8) in which the ventricles did not fill satisfactorily and subsequent ventriculography was necessary before a definite diagnosis could be made. The one death (Case 9) following encephalography was in a nine-year-old girl with a third ventricle tumor. The neurologic picture consisted of a child in coma who suffered from a bizarre type of convulsive seizures many times each day. Death occurred five days after encephalography and the tumor was found at autopsy.

TABLE II

Clinical Diagnosis	Roentgenograms	Encephalographic Studies	Diagnostic Value	Therapeutic Value and Comments
1. Suspected subdural hematoma following injury	Negative	Filling defect over right parietal lobe	Positive	Exploration; removal of clot
2. Suspected subdural hematoma following injury	Negative	Filling defect over left fronto-temporal lobes	Positive	Exploration; removal of clot
3. Suspected bilateral subdural hematomas following birth injury	Negative	Marked cerebral atrophy with dilated ventricles	Positive	No operation felt to be justified
4. Suspected bilateral subdural hematomas following birth injury	Negative	Filling defect over both parietal lobes	Positive	Bilateral exploration with removal of clots
5. Suspected subdural hematoma following injury	Healed fracture, left temporal bone	Filling defect left temporal lobe	Positive	Exploration; clot removed
6. Suspected hematoma following injury	Linear fracture, left frontal bone	Filling defect right parietal lobe	Positive	Exploration; removal of clot
7. Suspected subdural hematoma following injury	Linear fracture, right parietal bone	Normal encephalogram	Positive	No operation; 120 c.c. of cerebrospinal fluid replaced with 110 c.c. air
8. Suspected traumatic epilepsy	Negative	Normal encephalogram	Positive	No surgical procedure felt to be justified
9. Post-traumatic headache	Negative	Normal encephalogram	None	None: 90 c.c. of cerebrospinal fluid replaced with 85 c.c. air
10. Post-traumatic headache	Healed fracture, left frontal lobe	Moderate widening of cortical pathways over both frontal lobes	Indeterminate	None: 110 c.c. cerebrospinal fluid replaced with 100 c.c. air
11. Post-traumatic headache	Negative	Normal encephalogram	None	None: 80 c.c. cerebrospinal fluid replaced with 75 c.c. air
12. Post-traumatic headache	Healed fracture, right parietal lobe	Slight dilatation of ventricles and compression sulci right parietal lobe	Indeterminate; refused exploration	None: 130 c.c. cerebrospinal fluid replaced with 120 c.c. air
13. Post-traumatic headache	Healed fracture, right frontal bone	Slight widening of cortical pathways over both frontal lobes	Indeterminate	None: 90 c.c. cerebrospinal fluid replaced with 85 c.c. air
14. Post-traumatic headache	Negative	Right lateral ventricle partially filled; otherwise normal	Indeterminate; refused ventriculogram	None: 75 c.c. cerebrospinal fluid replaced with 70 c.c. air

Thus, it is felt that occasionally, in a case of suspected brain tumor, encephalography is indicated when there are no demonstrable signs of a marked increase in intracranial pressure. However, the possibility of being misled in localization must be borne in mind and it is my opinion that ventriculography is of far more value in localizing cerebral neoplasms when clinical signs are insufficient.

Traumatic Conditions.—The ever-increasing frequency of puzzling complications following head injuries may upon occasion warrant the use of encephalography for a means of diagnosis. In addition, a number of writers have reported beneficial results in unusually resistant cases of post-traumatic headaches. These gratifying rewards are based upon the theory that insufflation of air will break up many fine adhesions which had interfered with the normal circulation of cerebro-spinal fluid. This has not occurred in my experience, as will be shown in the following cases. Many of these unfortunate sufferers are relieved only by generous compensation or through much reassurance over the course of many months.

Encephalography was of distinct diagnostic value in eight of the above cases and possibly of some value in four other cases. As a therapeutic agent directed toward relief of post-traumatic headaches, this procedure was of no benefit It is important to state that in all of the above cases there was insufficient clinical evidence to warrant a diagnosis.

Congenital Defects.—Every clinician is confronted with the problem of the defective child and its anxious parents. Pancoast and Fay, and later, Crothers, Vogt, and Eley have discussed the value of pneumoroentgenography in children with fixed lesions of the brain. If for no other reason, encephalography, or preferably ventriculography, should be instituted to prevent doting parents from wasting hard-earned money in a vain search for a cure of a hope-

TABLE III

Clinical Diagnosis	Roentgenograms	Encephalographic Studies	Diagnostic Value	Therapeutic Value and Comments
1. Hydrocephalus	Not taken	Marked dilatation of ventricles and compression of both cerebral hemispheres	Positive	None: 200 c.c. cerebrospinal fluid replaced with 190 c.c. air
2. Indeterminate	Negative	Ventricles not visible	Negative; ventriculography supplemented	None. Ventriculograms indicated lesion of third ventricle. Congenital defect of third ventricle found at autopsy
3. Indeterminate	Negative	Defect of third ventricle	Positive	None. Corroborated at autopsy
4. Indeterminate	Negative	Defect of fourth ventricle	Positive	Exploration. Anomalous vessels constricting fourth ventricle
5. Hydrocephalus	Negative	Communicating hydrocephalus; obstruction at chiasmal cistern	Indeterminate; refused exploration	None: 150 c.c. cerebrospinal fluid replaced with 140 c.c. air

TABLE IV

Clinical Diagnosis	Roentgenograms	Encephalographic Studies	Diagnostic Value	Therapeutic Value and Comments
1. Headaches following encephalitis 2 years previously	Thin inner table left frontal bone	Wide cortical pathways and compression of both frontal lobes	Positive	Cerebrospinal fluid (120 c.c.) replaced with 110 c.c. air. Relief with dehydration diet
2. Headaches, emotional instability following encephalitis 2 years previously	Negative	Wide cortical pathways and compression of both frontal lobes	Positive	Cerebrospinal fluid (90 c.c.) replaced with 80 c.c. air. Relief with dehydration diet
3. Headaches following encephalitis 18 months previously	Negative	Wide cortical pathways and compression of both frontal lobes	Positive	Cerebrospinal fluid (85 c.c.) replaced with 80 c.c. of air. Relief with dehydration diet

lessly deficient child. Encephalography does not seem as valuable as ventriculography in some cases of hydrocephalus, and for this reason it is sometimes necessary to supplement the latter procedure when doubt exists as to the presence of an obstruction in the ventricular circulation. It is highly possible that some of the following cases might receive benefit at a later date when our knowledge of newer surgical attacks upon the ventricles becomes broader.

Inflammatory Conditions.—There have been occasional cases following in the wake of a severe encephalitis in which the symptoms were bizarre and the physical

TABLE V

Clinical Diagnosis	Roentgenograms	Encephalographic Studies	Diagnostic Value	Therapeutic Value and Comments
1. Epilepsy	Negative	Diffuse cerebral atrophy	Positive	None: 180 c.c. cerebrospinal fluid replaced with 165 c.c. of air. Rapid mental deterioration
2. Epilepsy	Negative	Communicating hydrocephalus; block at chiasmal cistern	Positive	Exploration. Adhesions around chiasmal cistern broken up. Convulsions definitely diminished in severity and frequency
3. Epilepsy	Negative	Normal encephalogram	Indeterminate	None: 100 c.c. of cerebrospinal fluid replaced with 90 c.c. of air. No improvement
4. Epilepsy	Negative	Compression of right parietal lobe	Misleading	Exploration for tumor: none found. Meningoencephalitis. Moderate improvement on dehydration diet
5. Epilepsy	Negative	Normal encephalogram	Indeterminate	None: 100 c.c. cerebrospinal fluid replaced with 95 c.c. of air. Placed on dehydration diet. Unco-operative. No improvement
6. Epilepsy	Negative	Moderately diffuse cerebral atrophy	Positive	None: 120 c.c. of cerebrospinal fluid replaced with 115 c.c. of air. Dehydration diet. Marked improvement
7. Epilepsy	Negative	Diffuse cerebral atrophy	Positive	None: 180 c.c. of cerebrospinal fluid replaced with 175 c.c. of air. Rapid mental deterioration
8. Epilepsy	Negative	Wide cortical pathways	Positive	None: 100 c.c. cerebrospinal fluid replaced with 90 c.c. of air. Marked improvement with dehydration diet
9. Epilepsy	Negative	Moderate cerebral atrophy	Positive	None: 120 c.c. cerebrospinal fluid replaced with 110 c.c. of air. Moderate improvement on dehydration diet
10. Epilepsy	Negative	Normal encephalogram	Indeterminate	Indeterminate: 80 c.c. cerebrospinal fluid replaced with 75 c.c. of air. Parents would not co-operate on diet. No seizures in past 18 months
11. Epilepsy	Negative	Normal encephalogram	Indeterminate	None: 80 c.c. cerebrospinal fluid replaced with 75 c.c. air. No co-operation on diet. Convulsions persist
12. Epilepsy	Negative	Diffuse cerebral atrophy	Positive	None: 100 c.c. cerebrospinal fluid replaced with 95 c.c. of air. Rapid mental deterioration

findings were absent or out of proportion with the history. It is in these few instances that encephalography has been of value as a means of diagnosis which led to institution of treatment affording definite relief.

Epilepsy.—Encephalography has been advocated as a diagnostic means in all cases of generalized convulsions. The supporters of the dehydration treatment feel that an encephalogram and measurement of cerebrospinal fluid content will regulate, to a relative degree, the amount of fluid restriction.

It is obvious that any adult suddenly seized with convulsions in the absence of a demonstrable cause or previous epileptic history, should receive the benefit of encephalography as a means toward detection of organic pathology.

There have been some reports that encephalography is of therapeutic value in the convulsive state, but it is questionable if this procedure is the sole therapeutic agent or if it is not an adjunct to other forms of therapy. Thus, it would be extremely difficult to evaluate the full benefit of encephalography unless a series of cases were kept under strict observation to rule out any additional form of treatment. In one of the following cases, the convulsions have ceased for eighteen months without further treatment purely because of uncooperative parents. This one case hardly seems to justify a feeling of reliance upon encephalography as a sole therapeutic agent.

SUMMARY

Encephalography has been of value as a means of diagnosis in a large percentage of the above cases when clinical signs were too meager to clarify each situation. However, as in all mechanical aids, too much reliance cannot be placed upon this procedure. As a therapeutic agent, encephalography has been of no value in my experience.

To obtain the full benefit of encephalography, there must be a thorough basic understanding of the pathology of the cerebrum and knowledge of the physiologic anatomy of the cerebrospinal fluid circulation, coupled with close co-operation between the neurologist, surgeon, and roentgenologist.

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RENAL RICKETS[1]

WITH REPORT OF A CASE

By BERNARD H. NICHOLS, M.D., *and* E. LEE SHIFLETT, M.D., *Cleveland Clinic, Cleveland, Ohio*

THE association of chronic kidney disease with renal insufficiency and delayed rickets in children and adolescents has been frequently stressed in the literature since Lucas, in 1883 (1), reported a number of cases of rickets associated with albuminuria. These occurred about puberty and he stated that the phenomena of late rickets and albuminuria are too frequently connected to be matters of chance and suggested for the ailment the term "rickets of adolescence." Fletcher's report (2) of a case of infantilism in a boy, aged six years, associated with chronic kidney disease, has been cited repeatedly as being the first definite recognition of the etiologic connection between chronic kidney disease and renal rickets. Barber, in 1920 (3), compiled a series of ten cases of stunted development, renal insufficiency, and the late bone changes of a rachitic nature and contributed the term "renal dwarfism." Thus were evolved the three terms used to describe the variable clinical manifestations of maldevelopment due to renal insufficiency in early life, the particular terms used depending on whether rickets, infantilism, or dwarfism is the predominant abnormality. The literature contains many case reports and the collected data have established renal rickets as a clinical entity.

Etiology.—A sufficient number of cases and enough clinical and pathologic data have been collected to establish the fact that this type of rickets is not the result of any one particular type of chronic kidney disease but may be associated with chronic interstitial nephritis, cystic kidneys, congenital or acquired obstruction of the urinary tract, urinary tract infections and calculi, nephritis secondary to systemic or local infections which terminate in chronic nephritis, or other lesions which produce renal insufficiency during the growth period.

Fig. 1. Anteroposterior view of the legs shows marked bowing, with cupping of the diaphyses of the lower end of the tibiæ and broadening of the upper end.

The mechanism by which the bony changes take place is not definitely understood and there are many controversial theories. Most of the theories are based on a disturbed calcium-phosphorus balance resulting from the inability of the kidneys to excrete endogenous phosphates. This presumably leads to an elevation of the blood phosphates and a lowered blood calcium. The lowered calcium and in-

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creased phosphorus content may be relative or absolute, or there may be a complete reversal of the usual ratio of calcium and phosphorus. This abnormal calcium-phosphorus ratio seems to be entirely independent of the mineral and vitamin constituents of the diet, and hence renal rickets is not regarded primarily a food deficiency disease. Mitchell (4) reasons that since the kidneys are unable to excrete the endogenous phosphates, the blood phosphorus should be higher than that usually found, and hence the body must be eliminating these waste products in some way, presumably by the bowel. He believes that the increased level of phosphates in the intestines can interfere with the absorption of the calcium by the formation of insoluble calcium phosphates which are excreted in the feces.

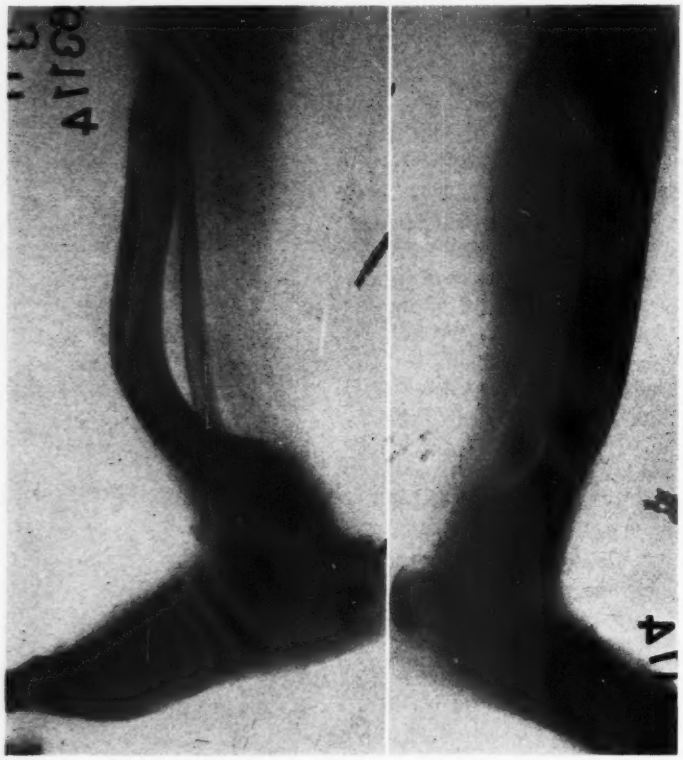

Fig. 2. Lateral view of the legs shows marked tibial bowing and rachitic changes about the epiphyses.

Pathology.—The outstanding pathologic finding is marked, and often results in practically complete destruction of the kidneys. Grossly, the kidneys are small, fibrotic, and contracted, and the histologic picture is one of advanced chronic interstitial nephritis. Associated pathologic findings in these cases include abnormal bone changes; renal and bladder calculi; hypertrophy of the heart, often associated with dilatation of the left ventricle, and sclerosis of the aorta and other large blood vessels.

The gross deformities of bone are bowing, genu valgum, genu varus, widening of the diaphyses, thickening, displacement and partial epiphyseal separation, fractures, and malunion. The microscopic changes in the bones consist of irregularity of the epiphyseal lines with islands of osteoid

Fig. 3. Outward bowing of both femurs. The diaphysis is markedly trabeculated and shows decreased calcium deposit.

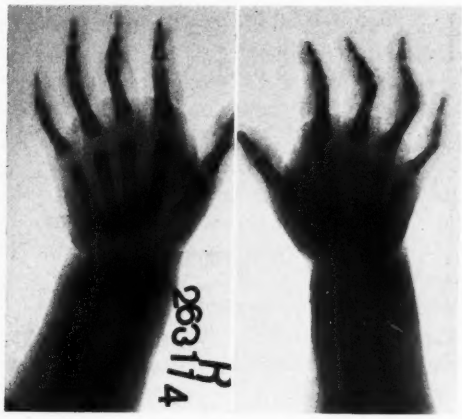

Fig. 4. Delayed appearance of carpal bones, and scanty calcium content. There is broadening of the diaphyses of the radii and absence of calcification in the lower end of the ulnæ.

tissue, irregular calcification and broad zones of loose connective tissue in which islands of osteoid tissue are embedded between cartilage and bone. The large islands of cartilage are bordered by dense calcium deposits which give to the bones the honeycombed and woolly appearance seen on the roentgenogram. The proliferative cartilage is irregular and calcification is defective. Trabeculæ are thin and the osteoid borders are narrow. Loose fibrous tissue surrounds and lies between the trabeculæ and islands of cartilage. The bone is soft and the cortex is thin. Hemorrhage may occur between the epiphyses and the diaphyses. There is a large increase in medullary fat.

Symptoms.—Renal rickets usually appears before the tenth year, and is most common in children under five years of age. The onset is usually insidious. Infantilism, dwarfism, or rickets may be the outstanding clinical picture and there are combinations and variables of these abnormal states. The symptoms are chiefly those of a chronic nephritis on which are superimposed rachitic changes and maldevelopment. The symptoms are variable and not all those characteristic of the disease are present in every case. Drowsiness, headaches, vomiting, anorexia, excessive thirst, polyuria, wasting, anemia, impaired renal function, retardation of growth and physical development, delayed or absent development of the secondary sexual characteristics, and rachitic deformities are the predominant signs and symptoms. In view of the renal damage, there is a surprisingly low incidence of cardiovascular signs and symptoms. Hematuria, renal pain, dyspnea, palpitation, visionary changes, high blood pressure, and edema are by no means outstanding symptoms.

The chief physical findings are genu valgum, parietal and occipital bossing, beading of the costochondral junctions, Harrison's sulcus, flaring of the epiphyses, "pigeon chest," flat feet, bowing of the long bones, and occasionally deformities from malunited fractures and genu varus.

The urea and non-protein nitrogen in

the blood are usually high. It is amazing that some of these children are able to carry on for years with a blood urea of 100 mgm. per cent or more (5). The specific gravity of the urine is usually fixed at a low level. Albumin may or may not be present at single examinations, but repeated urinalyses will usually reveal albumin in variable amounts in one or more specimens. Bacteria and pus may or may not be present. Casts are not constantly found. The phenolsulphonephthalein output is markedly decreased and urea clearance and other renal functional tests show marked impairment of function.

There is usually an abnormal calcium-phosphorus ratio. A normal ratio at one examination does not exclude renal rickets. There is a tendency to true acidosis which some have considered a protective mechanism against tetany.

Roentgenographic Findings.—The roentgenographic appearance of the bones in renal rickets is not pathognomonic as is attested by the variety of descriptions and classifications found in the literature. The picture is more or less characteristic of infantile rickets, but Mitchell (4) has noted in renal rickets greater translucency and a more spongy appearance of the bones. The roentgenographic picture seems to depend upon the age of the patient at the time of onset of the disease and the stage of the disease at the time of the examination. The roentgen changes are generalized diminution of lime salts, increased trabeculation, poorly calcified subperiosteal bone, osteoporosis, irregular and patchy ossification which gives a woolly appearance, irregularity and expansion of the epiphyses, bowing of the long bones, and partial epiphyseal separations and displacement. The most marked changes are usually observed in the region of the growth discs. Cupping is observed in some cases. Although a given picture may vary greatly from that usually observed in infantile rickets, the roentgenographic appearance is not pathognomonic. The roentgenologist cannot make a positive diagnosis of renal rickets unless the roentgenographic findings are correlated with the clinical and laboratory data.

CASE REPORT

The patient, a little girl who was five years and eight months old when she was first examined at the Cleveland Clinic, had long-standing symptoms of renal insufficiency and rickets. She had had a local ear infection since she was a few weeks old, and nutrition had always been difficult as the result of the careless administration of concentrated hydrochloric acid when she was six days old. She had pneumonia at the age of one year from which she apparently had recovered satisfactorily. At the age of one year and eight months she had varicella, and at about the same time the parents had first noticed evidence of rickets.

The exact onset of the kidney symptoms could not be determined, and it is impossible to state whether she had true infantile rickets before the age of one year and eight months and later developed renal insufficiency which kept up the rachitic condition or whether the kidney insufficiency developed first. The latter is more likely, for, in spite of the dietary problem, through forced feeding the patient had received a sufficient intake of food and antirachitic vitamin. She had never had convulsions and apparently there had been no uremic symptoms although her blood urea had been known to be greatly increased for two years before she was admitted to the Clinic. Although this patient may have had true infantile rickets, it is definitely established that the factor of renal insufficiency prevented healing on an adequate diet and adequate amounts of antirachitic Vitamin D.

There was a secondary anemia. She displayed marked rachitic deformities and also deformity as a result of malunion. Roentgenographic examination showed defective calcification, poorly calcified periosteal bone, trabeculation, delayed appearance of carpal bones, and partial epiphyseal separation. In addition, there

was some cupping of the lower end of the tibiæ. (Figs. 1 to 4.)

The marked renal insufficiency was indicated by polyuria, low specific gravity of the urine, the presence of albumin, the low phenolsulphonephthalein output, the low urea clearance, and the failure of the kidneys to excrete the dye when an attempt was made to get an intravenous urogram. The blood urea was high and the calcium-phosphorus ratio was normal. Cardiac enlargement, increased blood pressure, and visionary changes were not present in this case.

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INTERNATIONAL RECOMMENDATIONS FOR X-RAY AND RADIUM PROTECTION

Revised by the International X-ray and Radium Protection Commission at the Fourth International Congress of Radiology, Zürich, July, 1934

MEMBERS

Dr. R. Ledoux-Lebard (France), *Chairman*.

Dr. G. W. C. Kaye (National Physical Laboratory, England), *Honorary Secretary*.

Prof. R. Bär (Switzerland).

Dr. H. Behnken (Physikalisch-Technische Reichsanstalt, Germany).

Dr. R. Sievert (Sweden).

Dr. I. Solomon (Service d'Etalonnage de l'Hôpital St. Antoine, Paris).

Prof. F. Tank (Switzerland).

Dr. L. S. Taylor (National Bureau of Standards, U. S. A.).

Dr. E. Pugno-Vanoni (Italy).

INTERNATIONAL RECOMMENDATIONS

1. The dangers of over-exposure to x-rays and radium can be avoided by the provision of adequate protection and suitable working conditions. It is the duty of those in charge of x-ray and radium departments to ensure such conditions for their personnel. The known effects to be guarded against are:

(*a*) Injuries to the superficial tissues;
(*b*) Derangements of internal organs and changes in the blood.

The evidence available at present appears to suggest that under satisfactory working conditions a person in normal health can tolerate exposure to x-rays to an extent of about 0.2 international roentgen (r) per day. On the basis of continuous irradiation during a working day of seven hours, this figure corresponds to a dosage rate of 10^{-6} r per second. The protective values given in these recommendations are generally in harmony with this figure under average conditions. No similar tolerance dose is at present available in the case of radium gamma rays.

I. WORKING HOURS, ETC.

2. The following working hours, etc., are recommended for whole-time x-ray and radium workers:

(*a*) Not more than seven working hours a day in temperate or cold climates. For workers in tropical climates, shorter hours may be desirable.
(*b*) Not more than five working days a week; the off-days to be spent as much as possible out of doors.
(*c*) Not less than four weeks holiday a year, preferably consecutively.
(*d*) Whole-time workers in hospital x-ray and radium departments should not be called upon for other hospital service.
(*e*) X-ray workers, and particularly radium workers, should be systematically submitted, both on entry and subsequently at least twice a year, to expert medical, general, and blood examinations. These examinations will determine the acceptance, refusal for, limitation, or termination of such occupation.

II. GENERAL X-RAY AND RADIUM RECOMMENDATIONS

3. X-ray departments should not be situated below ground floor level.

4. All rooms, including dark rooms, should be provided with windows affording good natural lighting and ready facilities for admitting sunshine and fresh air whenever possible.

5. All rooms should be provided with adequate exhaust ventilation capable of renewing the air of the room not less than ten times an hour. Air inlets and outlets should be arranged to afford cross-wise ventilation of the room.

6. All rooms should preferably be decorated in light colors.

7. A working temperature of about 18°–22° C. (65°–72° F.) is desirable in x-ray rooms.

8. X-ray rooms should be large enough to permit a convenient layout of the equipment. A minimum floor area of 250 sq. ft. (25 sq. meters) is recommended for x-ray rooms, and 100 sq. ft. (10 sq. meters) for dark rooms. Ceilings should be not less than 11 ft. (3.5 meters) high.

9. High tension generators employing mechanical rectification should preferably be placed in a separate room from the x-ray tube.

III. X-RAY PROTECTIVE RECOMMENDATIONS

10. An x-ray operator should on no account expose himself to a direct beam of x-rays.

11. An operator should place himself as remote as is practicable from the x-ray tube. It should be borne in mind that valve tubes are capable of producing x-rays.

12. The x-ray tube should be self-protected or otherwise surrounded as completely as possible with protective material of adequate lead equivalent.[1]

13. The following lead equivalents are recommended under average conditions:

X-rays generated by peak voltages	Minimum equivalent thickness of lead
Not exceeding 75 K.V.	1 mm.
100	1.5
125	2
150	2.5
175	3
200	4
250	6
300	9
350	12
400	15

(*A*). *Diagnostic Work*

14. In the case of diagnostic work with other than completely protected tubes the operator should be afforded additional protection from stray radiation by a screen of a minimum lead equivalent of 1 millimeter.

15. Screening examinations should be conducted as rapidly as possible with minimum intensities and apertures. Palpation with the hand should be reduced to the minimum.

16. The lead glass of fluorescent screens should have the protective values recommended in Paragraph 13.

17. In the case of screening stands the fluorescent screen should, if necessary, be provided with a protective "surround" so that adequate protection against direct radiation is afforded for all positions of the screen and diaphragm.

18. Screening stands and couches should provide adequate arrangements for protecting the operator against scattered radiation from the patient.

19. Protective gloves, which should be suitably lined with fabric or other material, should have a protective value not less than one-third millimeter lead throughout both back and front (including fingers and wrist). Protective aprons should have a minimum lead value of 0.5 millimeter.

(*B*). *Treatment*

20. In the case of x-ray treatment the operator is best stationed completely outside of the x-ray room behind a protective wall of a minimum lead equivalent of 2 millimeters. This figure should be correspondingly increased if the protective value of the x-ray tube enclosure falls short of the values given in Paragraph 13. In such event the remaining walls, floor, and ceiling may also be required to provide supplementary protection for adjacent occupants to an extent depending on the circumstances.

21. Inspection windows in screens and walls should have protective lead values equivalent to that of the surrounding screen or wall.

22. In those cases in which an x-ray tube is continuously excited and treatment periods are regulated by means of a shutter, some form of remote control should be provided for the shutter to ensure that the

[1] The lead equivalent of a given thickness of protective material is that thickness of lead which is equally opaque to x-rays, excited at some specified peak voltage.

operator is not exposed to direct radiation while manipulating the shutter or filter.

Efficient safeguards should be adopted to avoid the omission of a metal filter in x-ray treatment. To this end, some means of continuously measuring the emergent radiation is recommended.

IV. ELECTRICAL PRECAUTIONS IN X-RAY ROOMS

23. The floor covering of the x-ray room should be of insulating material such as wood, rubber, or linoleum.

24. Where permanent overhead conductors are employed they should be not less than 9 ft. (3 meters) from the floor, and should consist of stout metal tubing or other coronaless type of conductor. The associated connecting leads should be of coronaless wire kept taut by suitable rheophores.

25. Wherever possible earthed guards or earthed sheaths should be provided to shield the more adjacent parts of the high tension system. Unshielded leads to the x-ray tube should be in positions as remote as possible from the operator and the patient. The use of "shock-proof" x-ray equipment in which the high tension circuit is completely enclosed in earthed conductors is recommended. In all cases, however, indiscriminate handling of x-ray tubes during operation should be forbidden. Unless there are reasons to the contrary, metal parts of the apparatus and room should be efficiently earthed.

26. Main and supply switches should be very accessible and distinctly indicated. They should not be in the proximity of the high tension system, nor should it be possible for them to close accidentally. The use of quick-acting, double-pole circuit breakers is recommended. Over-powered fuses should not be used. If more than one apparatus is operated from a common generator, suitable high tension multi-way switches should be provided. In the case of some of the constant-potential generators, a residual charge is held by the condensers after shutting down and a suitable discharging device should therefore be fitted. Illuminated warning devices which operate when the equipment is "alive" serve a useful purpose. The staff should be trained in the use of first-aid instructions dealing with electrical shock. If foot switches are used, they should be connected in series with an ordinary switch and should be so designed that they cannot be locked to keep the circuit "alive," and are not capable of being closed accidentally.

27. Some suitable form of kilovoltmeter should be provided to afford a measure of the voltage operating the x-ray tube.

28. Low flash-point anesthetics should never be used in conjunction with x-rays.

V. FILM STORAGE PRECAUTIONS

29. The use of non-inflammable x-ray films is strongly recommended. In the case of inflammable films, suitable precautions should be taken as regards their use and storage. Large stocks should be kept in isolated stores, preferably in a separate building or on the roof.

VI. RADIUM PROTECTIVE RECOMMENDATIONS

(*A*). *Radium Salts*

30. Protection for radium workers is required from the effects of:

(*a*) Beta rays upon the hands;
(*b*) Gamma rays upon the internal organs, vascular, and reproductive systems.

31. In order to protect the hands from beta rays, reliance should be placed, in the first place, on distance. The radium should be manipulated with long-handled forceps, and should be carried from place to place in long-handled boxes, lined on all sides with at least 1 cm. of lead. All manipulations should be carried out as rapidly as possible.

32. Radium, when not in use, should be stored in a safe as distant as possible from the personnel. It is recommended

that the safe should be provided with a number of separate drawers individually protected. The amount of protection should correspond to the values given in the following table; these values which are based on working conditions where there is proximity to radium may be reduced for larger working distances.

Maximum quantity of radium element gm.	Thickness of lead cm.
0.05	5
0.2	8.5
0.5	10
1.0	11.5
2.0	13
5.0	15
10.0	17

33. A separate room should be provided for the "make-up" of screened tubes and applicators, and should only be occupied during such work.

34. In order to protect the body from the penetrating gamma rays during the handling of radium, a screen of not less than 2.5 cm. of lead should be used, and proximity to the radium should only occur during actual work and for as short a time as possible.

35. The measurement room should be a separate one and it should preferably contain the radium only during its actual measurement.

36. Nurses and attendants should not remain in the same room with patients who are undergoing radium treatment with quantities exceeding 0.5 gm.

37. All unskilled work or work which can be learned in a short period of time should preferably be carried out by temporary workers, who should be engaged on such work for periods not exceeding six months. This applies especially to nurses and those engaged in "making-up" applicators.

38. Discretion should be exercised in transmitting radium salts by post. In the case of small quantities it is recommended that the container should be lined throughout with lead not less than 3 mm. thick. It is more satisfactory to transport large quantities by hand in a suitably designed carrying case.

(*B*). *Radon*

39. In the manipulation of radon, protection against the beta and gamma rays has likewise to be provided, and automatic or remote controls are desirable.

40. The handling of radon should be carried out, as far as possible, during its relatively inactive state.

41. Precautions should be taken against excessive gas pressures in radon plants. The escape of radon should be very carefully guarded against, and the room in which it is prepared should be provided with an exhaust fan controlled from the outside of the room.

42. Where radon is likely to come in direct contact with the fingers, thin rubber gloves should be worn to avoid contamination of the hands with active deposit. Otherwise, the protective measures recommended for radium salts should be carried out.

43. The pumping room should preferably be contained in a separate building. The room should be provided with a connecting tube from the special room in which the radium is stored in solution. The radium in solution should be heavily screened to protect people working in adjacent rooms. This is preferably done by placing the radium solution in a lead-lined box, the thickness of lead recommended being according to the table in Paragraph 32.

(*C*). *Tele-curie-therapy*

44. It should be especially pointed out that the use of large quantities of radium in tele-curie-therapy may involve the risk of considerable dangers to the operators unless proper precautions are taken.[2]

[2] The Commission welcomes information from those having special experience in this branch of radium treatment.

A ROENTGENOLOGIST'S VIEW OF THE MINIMAL TUBERCULOUS LESION

By C. C. BIRKELO, M.D., Roentgenologist at Herman Kiefer Hospital and Maybury Sanitorium, *Detroit, Michigan*

THE definition of the minimal pulmonary tuberculous lesion outlined by the National Tuberculosis Association, is that lesion which would occupy an apical area and a first interspace on one side, as its maximum limitations, without excavation.

The area of lung involvement may naturally be much smaller, or it may consist of several small areas of tuberculous infiltration, whose total space would no more than fill the above-mentioned maximum space. This classification does not include the childhood type of tuberculous infection, which may or may not show a parenchymal involvement, as well as lymph node enlargement or calcification. The supposition is that the process is active but definitely confined to the above-mentioned small space. Cavitations are not allowed in this classification, so that it becomes evident that few minimal lesions show any positive sputum. Most of them are exposure cases and the majority give very few, if any, symptoms, and would likely pass unnoticed if it were not for the x-ray examination. For this reason, the roentgenologist carries a great responsibility toward this type of lesion. He must know the physiology and anatomy and all variations within normal limits, as well as the common and rare pathologic lesions likely to occur in the lungs.

It is clearly evident that the earlier a tuberculous lesion can be definitely diagnosed, the better the chance for a more permanent repair. Complete eradication of the disease is not within our vision as yet, but how close we come to such an ideal will depend on how well we succeed in recognizing the first signs of pulmonary tuberculous disease or the minimal lesion.

Our x-ray department at Herman Kiefer Hospital has for many years served as a clearing house for all cases of discovered or suspected pulmonary tuberculosis in our metropolis. In the past four to six years, the volume of chest x-ray examinations has grown to tremendous numbers. In 1929 we made 14,216 examinations and in 1933 we made 22,133. It is our duty to find the earliest forms of the disease, as well as those cases with advanced lesions, and also to eliminate those cases that do not have the disease.

The most common non-tuberculous lesions which we encounter in this survey are bronchiectasis, bronchopneumonia, pneumoconiosis, mitral stenosis, and malignancy of the lung. All of these lesions have rather definite x-ray findings, so that they are usually identified at once and tuberculosis definitely ruled out. Just as surely as these above-mentioned non-tuberculous diseases have definite x-ray characteristics, so does also the tuberculous lesion have definite x-ray findings. I could easily assemble many cases of tuberculous and non-tuberculous lesions which look very much alike, and yet, the distinguishing features or signs are there, if properly interpreted, and it is up to us as roentgenologists to see them and know them. I know of no better way to accomplish this knowledge than the actual experience gained from seeing pulmonary tuberculosis in all its varied forms.

Let us first consider an orderly method to attack the problem of diagnosis of the minimal lesion. There are two main types of minimal lesions, namely, the exudative and the productive, and these two types are almost as distinctly differentiated from a roentgenogram properly made as they are differentiated in the gross postmortem examination. I have often been impressed with the similarity of a well-made roentgenogram of the chest and a cross-section of the lung at the postmortem table. Nearly everything the pathologist

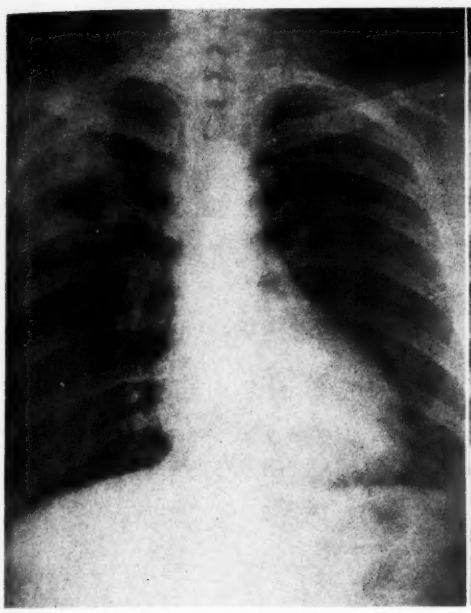

Fig. 1. A 27-year-old white woman, with no history of exposure. Minimal productive lesion at first interspace on the right.

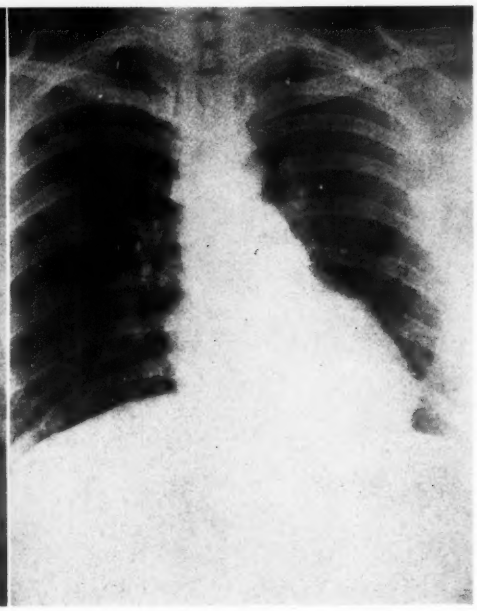

Fig. 2. Same case as in Figure 1, one year later. Lesion healed with fibrosis following phrenic operation.

can produce in the line of disease or abnormality has a definite density representation in the film. It is there, whether we see it or not. In some aspects, a roentgenogram surpasses the gross postmortem examination, in the fact that the air chambers and bronchioles are shown during their physiologic function and the air-filled spaces produce contrast for the pathologic conditions which may exist, whereas at the postmortem, all tissues of the lung are more or less sunken and collapsed and the process of decay already at work. In short, any alteration in the normal physiology of the lung will, in most instances, produce rather definite x-ray changes which we learn to recognize and identify. We have but to remember our knowledge of ten years ago—how hopelessly we then fumbled about for the proper classification of the things we saw—and how confident we feel to-day in naming the same lesions. I do not wish to infer that our knowledge of pathology was so much at fault at that time, but our comparisons with postmortem findings and the much improved technic of producing suitable roentgenograms are together responsible for the rapid strides made. So that, at the present time, we roentgenologists will probably have no more arguments in identifying lesions than do the pathologists. The matter of judgment based on experience will always enter in, regardless of how mathematically correct densities of different pathologic conditions may be recorded in our roentgenograms.

The exudative lesion is one with considerable perifocal inflammation. It is the acute form of tuberculosis and consists of small bronchopneumonic patches. The size and contour of the various patches vary considerably: some are circular and well defined; others are poorly defined and show a very ragged outline, but they all show that soft density of consolidation. When clearing and absorption take place, the perifocal exudate absorbs quickly

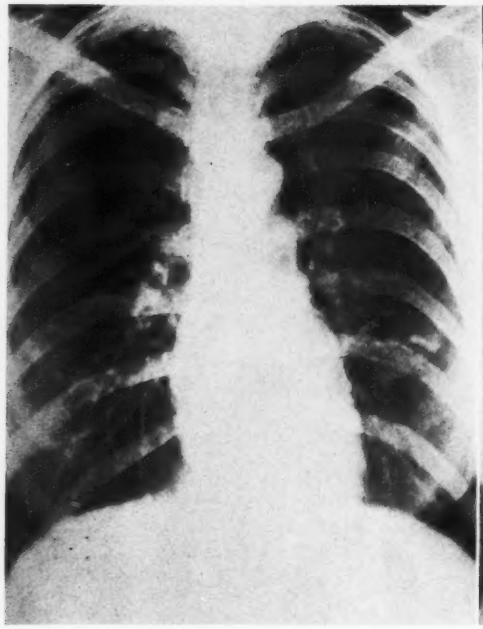

Fig 3. A 23-year-old white girl, with a definite history of exposure. Minimal mixed lesion in left infraclavicular region.

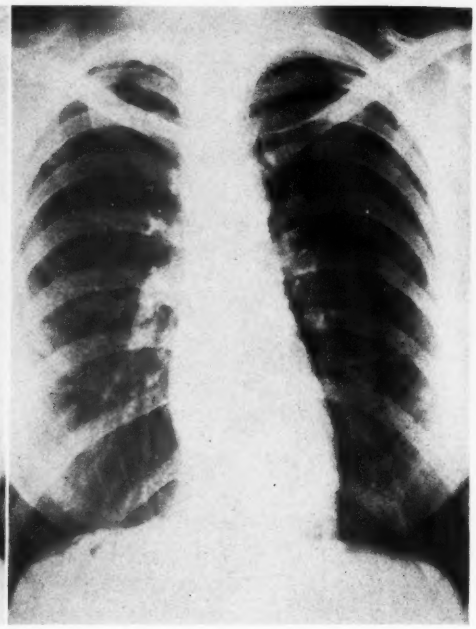

Fig. 4. Same case as in Figure 3, one year later. Lesion completely absorbed following hospitalization.

and the actual size of the tuberculous lesion may then be found to be much smaller than was originally imagined.

This type of lesion is very dangerous and it may extend rapidly and pass from a minimal lesion to a far advanced process if it is not put under control. In other words, as soon as the lesion is identified, all our forces of combat should be properly marshalled and a suitable method of attack selected and immediately applied. Careless waiting and inaction can result only in disaster, both to the patient and to the reputation of the roentgenologist. This type of lesion has often been compared with pneumonia in acuteness and rapidity of its attack and extension. It is indeed acute, but it does not resemble pneumonia in the time involved in producing appreciable consolidation, or in any other way. We have here records of all varieties of lesions: those which rapidly increased or spread as well as those which rapidly improved. The reason we find what appears to be acute pneumonic types of tuberculosis is, in most instances, because an early study has been neglected and undertaken only when the patient is incapacitated.

In the past three years we have examined roentgenograms of 13,000 school children, finding among them several cases of well-developed minimal and moderately advanced tuberculous lesions, often highly exudative in type, but in no one instance have we encountered extensive or massive consolidations, commonly called fulminating types of tuberculous lesions. If any tuberculous lesion, regardless of its type, comes on with the suddenness of pneumonia, I have never seen it, and I feel that statements to the contrary are exaggerations of actual facts. That it may develop rapidly and show extensive spread in a few weeks or a few months, is both true and a common experience here. It is in this exudative type in which such changes do occur.

The second class of lesion is the productive type. As its name implies, this is

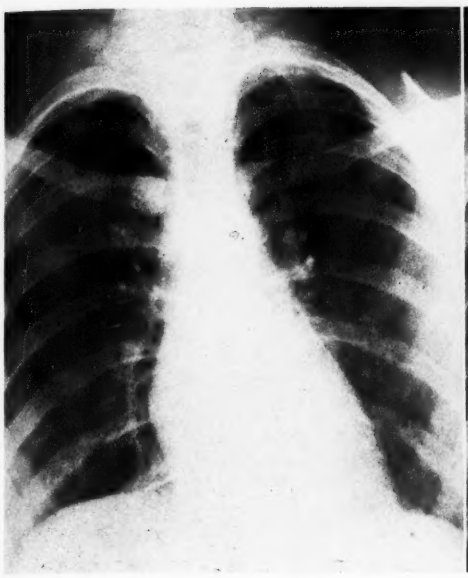

Fig. 5. A 13-year-old colored girl, with calcifications on both sides. Exudative infiltrations in the left apical region.

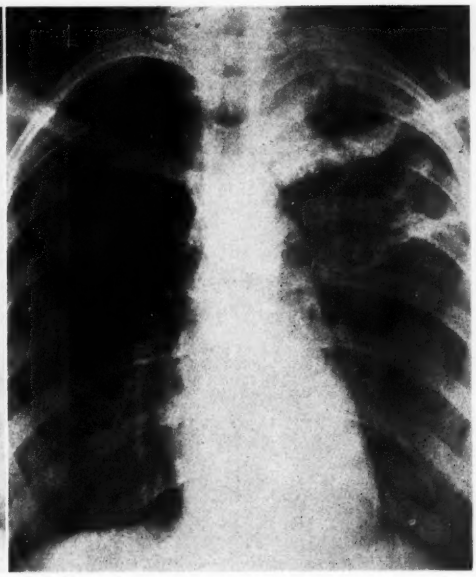

Fig. 6. Same case as in Figure 5, seven months later, showing extensive involvement in the upper third of the left lung, with excavations and positive sputum.

the lesion which shows very little perifocal inflammation, but does show some fibrosis or scar formation. This is the lesion which forms the basis for the former opinion that tuberculous lesions are tremendously slow, both in their spread and progress, as well as in clearing or healing. This type of lesion usually leaves some scar by which we may later identify a previous lesion. It also is the cause of the earlier opinion that, once a tuberculous lesion has existed, some identifying scar or mark will result and always remain. Now we feel that we can as truthfully state that an exudative lesion in the adult will often clear as completely as a chronic fibrotic type will leave a scar (Figs. 1 and 2, 3 and 4).

Then, when this type of lesion is encountered, we know that the condition is not so acute and that we have more time on our hands for deliberation. One thing is certain, that both types of lesions are capable of great damage or extension, with bad results if neglected or unrecognized, and, with neglect, a chronic productive lesion may easily become both acute and exudative. The important problem still remains in the early recognition of the minimal lesion.

It should be of interest at this time to show how much, if any, improvement we are making in our attempt at an early diagnosis. Table I shows the classification of cases entered at Herman Kiefer Hospital in the various years.

TABLE I

	Minimal	Moderately advanced	Far advanced
1921	10.1%	14.4%	75.5%
1926	10.0%	14.5%	75.5%
1931	13.3%	25.1%	61.6%
1932	15.4%	28.6%	56.0%
1933	15.4%	32.5%	52.1%

This shows a slow but gradual increase in the number of minimal cases entered at the expense of the other classifications, particularly the far advanced. It is very encouraging and probably universally true, especially in this country, that a slow but gradual improvement is under way, and it need not be doubted that these results are obtained only by constant and un-

Fig. 7. A 6-year-old white boy, with history of exposure. Note small circular infiltration at left base with small central calcification.

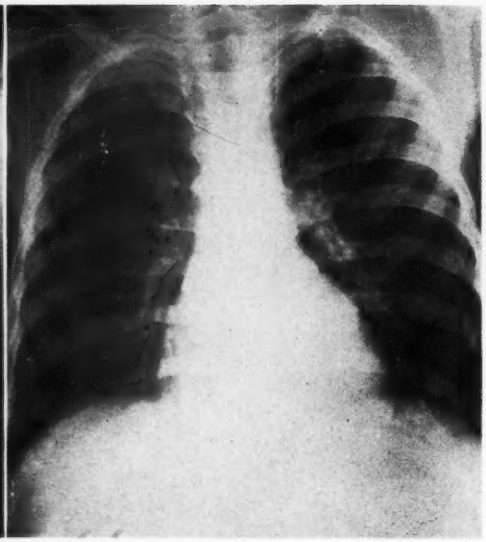

Fig. 8. Same case as in Figure 7, three years later. Calcification process at left base is complete.

tiring efforts of the medical profession in educating the public in the need of early diagnosis.

During the period from 1930 to 1934, we examined a number of cases of exposure and positive tuberculin reactors (Table II), in the Out-patient Clinic of this hospital, finding the number of tuberculous cases indicated and the number and percentage of minimal lesions, as shown.

TABLE II

	No. of cases examined	Minimal	Percentage
1930	17,327	301	15.2%
1931	16,492	406	20.8%
1932	13,084	290	17.8%
1933	16,542	300	19.2%

From these figures we may reasonably assume that the percentage of minimal cases found is slowly but surely increasing and mostly at the expense of the far advanced cases, which dropped from 55.3 to 48.8 per cent in the same time period.

To determine the location of minimal lesions in the lung, 300 cases were reviewed and all but 5 per cent were found in the upper third of either lung, with very nearly equal frequency on the right and left sides. Supraclavicular lesions were not uncommon but more often combined with first interspace lesions. It is generally recognized that supraclavicular lesions are less likely to extend downward and spread than are other lesions, like the infraclavicular type. I should like to add that this is true in the productive type of lesion and not in the exudative type, as I have quite a number of cases on record showing a definite downward spread from a purely supraclavicular lesion (Figs. 5 and 6).

Mid-lung lesions and also basal lesions are rare in the minimal class and usually found in reinfection or extensions from the childhood type of disease. The safest statement to make is perhaps this, that middle and basal lung lesions usually represent extensions from above and are often more advanced tuberculous lesions.

I have often been asked at what age period the greatest number of minimal lesions occur. Our statistics on this point differ from year to year and this question,

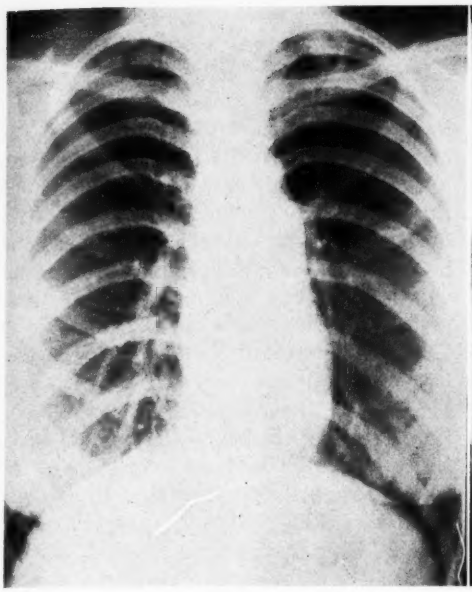

Fig. 9. A 15-year-old white school girl, with no history of exposure. Left apical, circular, exudative lesion, showing the beginning of excavation.

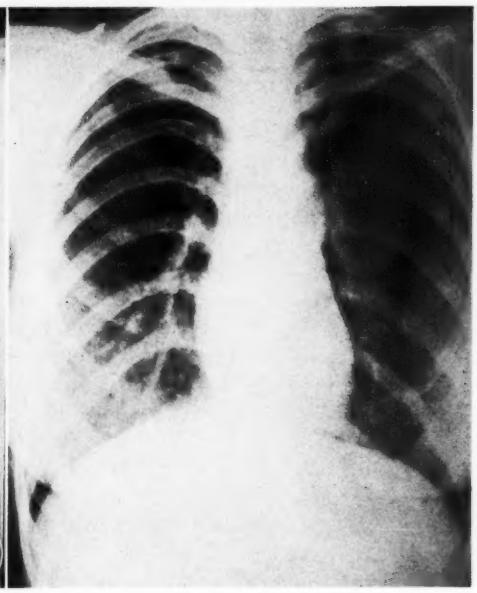

Fig. 10. Same case as in Figure 9, about a month later. Lesion is the same in size but the cavity is larger.

as well as the question of acuteness of the disease, can best be answered in this way: the minimal lesion may occur at any age and its acuteness undoubtedly depends on the dosage of the tubercle bacilli received. One of the most acute cases I have ever observed was in an employee who had worked here for twenty or more years and was about 55 or 60 years old at the time. He became acutely ill and the first x-ray examination showed no disease, while in a matter of two or three weeks he had an extensive miliary infiltration of both lungs. The dosage of bacilli which found its way into his blood stream had undoubtedly been great, and surmounted all his powers of resistance. The toleration dose for any individual may, and undoubtedly does, change from time to time, inasmuch as we have many cases of exposure that are free from disease at the first examination, yet at a second and third examination show definite evidence of either active or healed lesions. They were undoubtedly as much exposed at the first examination as they were later, when they knew about the source of infection, and yet, a period came when the resistance was sufficiently low for the disease to gain a foothold.

I also call to mind a far advanced case discovered after about a third of a lung had excavated. This patient's brother had occupied the same bed with him from childhood and yet had no tuberculosis or signs of any former infection, such as a calcification, after a two-year period of repeated examinations. The brother, who is free from tuberculosis, has always been vigorous and in excellent health, whereas the one with the far advanced lesion has never been strong. His source of exposure, as far as we could learn, was a fellow-workman with whom he was friendly, but they were not sufficiently friendly to visit each other after working hours. The other eight members of this family are also in good health and have not shown any signs of active or healed tuberculosis in the two-year period under observation.

In this family there must have been a continuous and generous dosage of infection for every member, in the year and a half during which the tuberculous brother must have had the infection, because when I first examined him he coughed considerably and raised generously and the material was loaded with bacilli in each specimen examined.

From many such experiences, it is reasonable to conclude that what is a safe dose to-day may not be safe to-morrow. We are all shocked at the tremendous ravages made by tuberculosis among the colored people, but there is a valid explanation for this in the fact that their living conditions are nearly always the worst in any city. Their daily dosage of tubercle bacilli is probably over and beyond our imagination.

Some years ago, I participated in a campaign against smallpox in the course of which a house-to-house canvass was made through the colored districts, to locate those unprotected individuals. It was found that several families not only occupied the same house, but slept in relays in the same bed, so that three families would sleep eight hours each in it. Now, then, is it past our imagination to understand why these people get an over-exposure or an over-dose of tuberculosis, if some one member of any of these families has an active excavating tuberculous lung involvement?

It has never been proven to my satisfaction that any one family, group, or race has any more resistance toward tuberculosis than any other. I think it has been pretty well shown that children of tuberculous parents do not suffer any more frequently from tuberculosis than do others, after they have once been removed from their source of infection.

This brings up the questions, When are sources of infection removed from a person's own system, once tuberculosis has been there? What can we tell with our x-ray examination or any other means at our disposal about the completeness of any healing process?

There are several ways in which a pulmonary tuberculous lesion may heal: by calcification, by formation of fibrosis or scar tissue, or by complete absorption of the entire lesion. Calcification is certainly confined to the first two decades of life and it is indeed very rarely found in the adult. During these past years of seeing a tremendous number of tuberculous lesions and re-examinations at regular intervals, I recall only three cases in which healing by calcification occurred in the adult. Two of these patients were in their twenties and one was over thirty years old. All of them showed extensive blood-borne seedings in both lungs which healed by calcification in about a year or so. So, then, we can safely state that this type of repair or healing belongs in the early years of life, just as the calcifying process which goes on in epiphyseal cartilage, and again directly opposite to the age period when the costal cartilage calcifies. Why this process of repair is confined to this age period is not known, and it bears no direct relation to any diet or other physiologic factors so far discovered. Calcifications are both common and extensive in the colored people, but apparently no more so than in the whites, given equally extensive lesions. There has been much controversy about the safety of a calcified area as regards a possible source of re-infection.

We have often observed very small and early deposits of calcium form about a small lesion and also in the center of a lesion, and, as time passes, the entire lesion becomes calcified. Later some absorption takes place, leaving a small solid mass of bony density (Figs. 7 and 8). Before this process is complete, it is naturally a source of possible re-infection. We also know that tubercle bacilli may be found in calcifications five or ten years following the first calcium deposit. The general rule which we have adopted of regarding a calcified lesion as safe, when the patient is past twenty years, works out very well, and I know of no instance in which such a re-infection has actually occurred, after this period of life. On the

other hand, I remember distinctly the cases of two girls who had formed extensive calcifications of bilateral extensive tuberculous lesions, and both came down with generalized blood-borne re-infection and passed out, in spite of all attempts at treatment. This disaster occurred at the puberty period in both instances, and the change in physiology occasioned at this period had probably a good deal to do both with the re-infection and the end-result. Here the calcifying processes could not have been complete, although they appeared very dense.

The great majority of our minimal lesions heal with fibrosis. The fibrous scar may or may not absorb quite completely, depending on its density and size. From the density and appearance of the fibrosis, it is quite possible to judge with a fair degree of accuracy as to the possible activity of a given lesion, and such an opinion, when found to be accurate, is indeed a great help in regulating the treatment to be given. It is this ability to judge a lesion from its appearance which makes it possible to empty hospital beds and make room for other patients in greater need of hospital care. We have long ago given up the idea of letting rest in bed be the proper treatment and I think our results will prove the correctness of this view.

At a regular conference, each case hospitalized is brought up for disposition as well as classification and the treatment decided upon is the one which will yield the quickest result. I have charted the minimal cases in the Herman Kiefer Hospital for the past five years and the diagram speaks for itself. Unless their home conditions were exceptionally good, all cases that were sent away from the hospital went to convalescent homes for longer rest periods. The active treatment decided upon was given here and it must have been sufficient, because we have very few of these cases that have come back to us later with more tuberculosis.

TABLE III.—MINIMAL CASES AT HERMAN KIEFER HOSPITAL

Year	No. cases entered	Average age	Average no. days in hospital	Improved	Arrested	Unimproved
1929	27	32.5	75	22	0	5
1930	131	30	103	96	17	18
1931	172	25.5	89	126	15	31
1932	158	27.5	105	118	18	22
1933	166	28	95	121	24	21

The lesions which disappear entirely are usually of the exudative type. These are the most dangerous and should receive some active treatment, such as a phrenic operation, and I feel free to state that the future will demand at least that much assistance be given each patient with such a lesion, no matter how small.

The size of the lesion should really have no weight in making a diagnosis of tuberculosis. I have watched very minute lesions in the parenchyma heal with fibrosis and calcification, proving my original diagnosis. I feel a great deal like the bacteriologist who has learned to identify his bacteria from colony characteristics. We have such colony characteristics of the tubercle bacillus in the lung, and we should be able to recognize them regardless of size (Figs. 9 and 10). I am not presenting this as something new, because I am sure the majority of roentgenologists are conversant with all that I have suggested, but these days we have such a variety of specialists, each holding up a roentgenogram, each one feeling fully competent of pointing out all that is there—and are they? Not so long ago, a physician practising another specialty was showing a beautiful series of bronchiectasis with lipiodol injection, and casually made the statement that the x-ray films made without lipiodol showed just nothing. As a matter of fact, nearly all of these films showed evidence of bronchiectasis and had been so interpreted.

It is such statements as these, carelessly made, which we have to disprove and live down. We see so much at present about the early detection of tuberculosis with the fluoroscope, and I certainly wish to

issue a protest in this regard. That is not the ideal way to wage a campaign against the early tuberculous lesion. We tried it here and had to give it up, and I both know and feel that I need all the very best film can show up to make a proper interpretation; the fluoroscope does not show enough. It is not safe to eliminate as nontuberculous, those patients who show no fluoroscopic signs or findings.

With so many commercial organizations practising medicine in the most frugal manner, we will have such things to contend with. It is this sort of thing that makes it necessary to send out a plea for the recognition of the minute tuberculous lesion, as I am now doing: it must not be passed up.

SUMMARY

1. The striking resemblance between a postmortem cross-section of a lung and a well-made x-ray of a lung is worthy of special notice.

2. The minimal lesion is the most important tuberculous lesion of all, because it has a definite promise of a complete cure.

3. Learn to recognize the different varieties of minimal lesions in order to give the best possible advice to the referring physician.

4. Learn the favorite sites for a tuberculous lesion in the lung and make use of all probable factors in supporting your opinion, as it is often almost as detrimental to a young life to have a diagnosis of tuberculosis mistakenly attached as it is to have the early lesion missed.

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ENCEPHALOGRAPHY IN ALZHEIMER'S DISEASE

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THE clinical entity known as Alzheimer's disease was first described by Alzheimer (1), in 1907, in a pathologic study of brain changes occurring in a mental disorder in the presenile period. The disease process was subsequently named after him by Kraepelin, and has been the object of much study and many reports since the original description. It was originally regarded as a presenile psychosis because of the close resemblance of the pathologic changes to senile brain changes. The great majority of reported cases are in the fifth, sixth, or seventh decade of life, although the same clinical and pathologic picture has been reported in a woman of 31 by Barrett (2), in 1913, and in a boy of 15 by Malamud and Lowenberg (3), in 1929. Other cases reported as Alzheimer's disease (by Schnitzler, patient aged 32; Schaffer, patient aged 28, and Weimann, patient aged 37) are not generally accepted as typical of the disease (Gruenthal, 4). Lowenberg and Rothschild (5), in 1931, reported an atypical case with onset at 37 years of age which was regarded as toxic in origin.

In a special consideration of the etiology of Alzheimer's disease, Malamud and Lowenberg (3) conclude that this clinicopathlogic syndrome may be caused by a variety of factors, the chief of which may have something in common with that which is causative of such changes in senility. This does not exclude, in their opinion, the possibility that factors altogether independent of senility may also bring about the same condition. Arteriosclerosis and syphilis bear no relation to the disease.

TYPICAL FINDINGS IN THE DISEASE

As was pointed out by Gruenthal (4), the clinical findings are remarkably constant in even a large group of cases.

Mental Picture.—The mental symptoms are usually the first evidence of the disease, which appears with a very gradual onset. Forgetfulness is characteristically the first symptom and soon the patient begins to mislay articles and to lose his belongings. The patient may be aware of his inability to think accurately and quickly and often he is concerned with the nature of his mental change. The memory loss progresses to confusion, with the frequent further handicap of apraxia and aphasia. Emotional instability is often conspicuous, with the occurrence of irritable periods and temper outbursts interspersed with periods of mild euphoria. The mental picture progresses to complete mental failure.

Neurologic Picture.—The most characteristic of the neurologic findings are the aphasia and apraxia which are often more marked on one side than on the other. Convulsions are not infrequently reported and focal signs are common, particularly hemiplegia, bulbar disturbances, and muscular atrophy.

Pathologic Picture.—Grossly there is brain atrophy, even to a difference of 20 per cent between the brain volume and skull capacity. Lowenberg and Rothschild (5) demonstrated a marked hemiatrophy of the brain at autopsy in one of their cases, a finding similar to the case presented here, as shown by encephalography. Microscopically there is a rarefaction of the cortical cell layers, a tremendous number of senile plaques (in direct proportion to the clinical severity of the disease), and a neurofibrillar degeneration (Grinker, 6).

THE USE OF ENCEPHALOGRAPHY

As has been indicated, the occurrence of focal signs in this disease is common. No doubt in many instances the diagnosis is somewhat uncertain because of the signs, particularly in instances of unilateral distribution. It is highly desirable to rule out a focal disturbance such as a

tumor. In the case cited below there was some slight question as to the possibility of a corpus callosum tumor and for differential diagnostic reasons encephalography was employed.

The use of encephalography in establishing the diagnosis of Alzheimer's disease has probably been employed in many instances. However, its special study has not been the subject of any of the numerous recent reports of encephalographic investigation. While no complete survey of the literature has been made, the more recently reported encephalograph studies do not reveal special mention of the findings in Alzheimer's disease. Friedman, *et al.* (7) include one case of "degenerative disease of the brain," and Grant (8) includes four cases of "cerebral arteriosclerosis." Harris and Hauser (9) refer to a "degenerative disease of the brain, with marked arteriosclerosis" which they believed was probably a tumor. Dixon and Ebaugh (10) refer to a death in an arteriosclerotic patient following the procedure and believe arteriosclerosis to be one of the common contra-indications to its use.

CASE REPORT

The patient was a white woman, a farmer's wife, age 56. The chief complaint was confusion beginning about two years ago, with increasing memory disturbances and emotional instability. Referred by Dr. E. A. Evans, of Conway Springs, Kansas.

Family History.—The father died at the age of 53, of asthma, when the patient was 14. The mother died at the age of 82 of cancer of the pyloris; there was no apparent mental disturbance in either one. The patient was the eighth of twelve children; the oldest sister died at the age of 67 after having been confined to bed for twelve years with rheumatism and what was regarded as arteriosclerosis. The third child in the family had neuritis at the menopause so that "her hands were drawn." The fifth child had diabetes. Otherwise the family history seems essentially negative.

Developmental History.—The patient went through grade school, taught music for a while, and at the age of 17 married her present husband—now in good health. She had spent her life on the farm, had been interested in friends, church work, and her children. There was a son aged 37, and two daughters aged 34 and 20, all of whom were well. The patient had a convulsion when the youngest child was about four days old, but there was no further difficulty of this sort. She had had occasional attacks of asthma for the last five or six years, sometimes very severe. She had always been a heavy woman, weighing about 200 pounds with a maximum of 250 pounds. She ate excessively and abnormally of sweets. She had always been constipated and had resorted to a laxative daily for several years. She passed the menopause at the age of 50.

Present Illness.—In 1928, at the age of 50, the patient had influenza, followed by a loss of weight of about 60 pounds over the next six months. The family attempted to get her to go to a physician but she steadfastly refused until practically forced to do so. At this time a diagnosis of toxic goiter was made, associated with the menopause. Following rest in bed in a hospital for two months she seemed to be quite herself.

No further difficulty occurred until about the age of 54, when the family noticed that she was becoming forgetful, was not quite so accurate in her work, and began losing things. Often she would misplace articles and was concerned about her memory loss. Her concern increased to a worry over her financial situation, and then about many things, apparently developing a rather typical picture of mild depression. In June, 1933, she fell down the cellar steps; it was not known whether or not she lost consciousness but in any event she escaped with only a bruise on her knee. Following this accident, the family noticed that she slipped mentally, becoming confused. Her confusion was intermingled with emotional instability, particularly outbursts of temper and ir-

ritability. As her confusion increased, her depression decreased.

The family noticed that she seemed to go to the left of things and used her left hand much more than she did her right. They noticed that she would make mistakes and when, asked for a knife, she would often give a fork. She would put sugar in her coffee with the handle of her spoon rather than with the bowl, and occasionally would appear impatient with the difficulty she was having in using her eating utensils and eat directly with her fingers. They noticed that she often had difficulty in finding words to express herself.

Physical Examination.—The patient was an obese, white female, unco-operative and objected throughout the examination to the various tests. Weight 213 pounds; height 5 feet, 3 inches. The conspicuous pathology noted was a red, dry tongue, hypertrophied tonsils, moderately enlarged heart with faint sounds, lacerated cervix, blood pressure 164/90, pulse rate 90, and the excessive obesity, particularly marked about the trunk.

Neurologic Examination.—The cranial nerves showed no gross pathology. The right fundus showed extreme thinning of the arteries and in the left disc there was a slight haziness in a small arc on the nasal border. The pupils reacted promptly to light and accommodation in a very slightly restricted radius. The right nasolabial fold was slightly shallower than the left, and the right-hand grip was a shade weaker than the left. In the motor system there was no gross pathology except as noted in the performance of skilled acts. There was no disturbance in gait, no paralysis, and no change in muscle tone. There was a slight suggestion of atrophy of the muscles of the dorsum of the right hand. There were no gross disturbances of the sensory system. The reflexes were equal and active and there were no definite pyramidal tract signs.

Skilled Acts.—The patient could not write. She grasped a pen very clumsily with either hand and misread simple, large letters. She grasped a comb after naming it and rubbed it down her nose with either hand in illustrating its use. She became confused at the simplest commands and mixed left and right. She misnamed simple objects, calling them by the name of an attribute or a function, *viz.*, a "write" for a pen. She was distinctly more clumsy in the use of her right hand than of the left. She expressed herself fairly well in simple, spontaneous speech. There was an element of psychotic negativism in some of the patient's errors and incapacities.

Mental Examination.—The patient was so extremely childish and confused that any co-operation was handicapped by these factors. She was disoriented for time, place, and person and there were very gross memory lapses. Her difficulty in expressing herself in part accounts for these, but a small part of her verbatim conversation is quoted to indicate her confusion and her disorientation. (What date is it?) "I don't know." (What month is it?) "I don't know." (What year is it?) "I don't know." She giggled. (What season is it?) "I don't know." (Is it spring, summer, fall, or winter?) "Well, it's fall. No, it's winter." (Is it hot in winter like this?) "Yes, awful hot." (How old are you?) "I'm"—a long pause. "I'm Dr. Evans' age." (How old is he?) "That's—I'm—let's see—40, I think." (Where is your home?) "I live in that"—a pause. "Well, uh—Kansas—Topeka." (How long have you lived there?) "Oh, I don't know." (How long have you been there?) "I don't know." (About how long?) "Oh, I don't know."

While she was under observation for a period of a week she showed no marked emotional instability except in flightiness, a tendency to negativism, and the external manifestation of a frequently recurring shallow emotionless smile. The history indicates periods of marked emotional instability.

Laboratory Examination.—Hemoglobin, 80 per cent; red blood count, 4,390,000; white blood count, 11,800; neutrophils,

Fig. 1. Anteroposterior view. See text.

Fig. 2. Lateral view. See text.

78 per cent; small lymphocytes, 20 per cent; large lymphocytes, 2 per cent; blood Wassermann and Kahn tests negative. Urinalysis: acid; specific gravity, 1.031; albumin negative; sugar negative; epithelial cells few; amorphous urate crystals, few. A second specimen showed a slight trace of albumin, occasional pus cells, few epithelial cells. Spinal fluid cell count 2, protein 55. Wassermann negative in both antigens. Colloidal gold curve entirely negative.

Encephalography.—From the examinational data given above the tentative diagnosis of Alzheimer's disease was made, but in view of the fact that there was a marked unilateral apraxia and a suggestion of muscular atrophy along with the aphasia and agraphia and alexia, it seemed advantageous to rule out the remote possibility of a brain tumor. An encephalography was recommended and carried out by Dr. Leo Stone of our Staff, according to the general plan recommended by Dyke and Davidoff (11). The patient was admitted to the sanitarium twenty-four hours before the encephalography. She was given sodium amytal the previous night and 6 grs. in the morning, along with a quarter grain of morphine before coming to the x-ray room where the procedure was carried out. The patient cooperated very well. Cerebrospinal fluid to the amount of 185 c.c. was removed and 180 c.c. of air injected. Two test roentgenograms were taken after 30 c.c. and 120 c.c., respectively, of air had been injected. The plates here shown were made at the completion of the air injection (Figs. 1 and 2).

It was noted that during the course of the removal of spinal fluid, the first 30 to 40 c.c. flowed very slowly. After the first 75 c.c. the speed of the flow greatly increased and continued throughout the remainder of the procedure. The fluid was still flowing freely even when the procedure was stopped at the removal of 185 c.c., but because the plates were diagnostic, it was deemed unnecessary to remove more. The explanation of this change in rate of flow is not clear. One might postulate the possibility that the insufflation of air may have broken some adhesions, and thus permitted a freer flow. If such a block in the spinal fluid pathway was the case, one might expect a possible therapeutic benefit from the procedure.

The patient reacted very well throughout the procedure, developing a severe

head pain, but vomited only once. She attempted to co-operate through the entire operation and her very mild reaction may in part be explained by her dulled sensorium and the absence of any preoperative anxiety. She remained drowsy for the following twenty-four hours but gradually gained, and on her discharge six days later seemed brighter and more stable emotionally than prior to the encephalography.

Interpretation of the Roentgenograms Following the Air Insufflation.—The two most instructive roentgenograms are here reproduced. In Figure 1, the anteroposterior view, we see a very gross dilatation of both lateral ventricles, the left much more marked than the right. The third ventricle is also visualized clearly, indicating no blocking of the spinal fluid pathway that might have produced internal hydrocephalus. In Figure 2, the lateral view of the encephalogram, we see the smaller right ventricle superimposed over the much more dilated left lateral ventricle, indicating in both of these plates a very marked atrophy of the substance of the cerebral hemispheres, particularly on the left side. There are several areas of air over the cortex though no large accumulations, but sufficient to suggest in addition some cortical atrophy. There is no indication or evidence whatever of any sort of focal lesion and the ventricles are in no wise displaced or distorted. Both of these encephalograms indicate, then, a very marked atrophy of the brain substance, much more marked on the left side, and explaining the more marked neurologic symptoms on the right side.

DISCUSSION

In this case we have an excellent example of the use of encephalography in Alzheimer's disease to conclusively rule out the existence of any tumor which might remotely be thought to be present in view of the neurologic findings. Further, the encephalography indicates the explanation of the symptoms and supports the repeatedly reported observations of the pathology, namely, the very marked brain atrophy, in this instance more pronounced on the one side than on the other. We believe that in this case the encephalography was a very helpful differential diagnostic aid in conclusively showing the clinical picture to be Alzheimer's disease.

SUMMARY

A case presenting the typical history, physical findings, and mental picture of Alzheimer's disease has been presented, in which encephalography was used helpfully to exclude the remote possibilities of a brain tumor and conclusively to support the diagnosis of Alzheimer's disease. We have found no special study of the use of encephalography in Alzheimer's disease, and feel justified in recommending it.

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CALCIFICATION OF THE ABDOMINAL AORTA[1]

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CALCIFICATION of the abdominal aorta is not an uncommon finding in the routine roentgen investigation of the lumbar area. While this condition has not been frequently reported, it is probably more common than is usually supposed. The literature contains but few references regarding the effects produced by this lesion upon the digestive organs. It is, therefore, of sufficient interest to warrant a particular study of this condition. In considering this affection an attempt will be made to correlate the roentgenologic and clinical picture of a group of cases of calcification of the abdominal aorta, emphasizing the gastro-intestinal manifestations.

The significance of calcification of the abdominal aorta and its relationship to digestive disturbances has not been fully recognized. Ridlon and Berkheiser (1) report three cases of calcification of the thoracic and abdominal aorta with backache as a predominant symptom. Gutmann and Routier (2) report 16 cases of abdominal aortitis with gastralgic manifestations, but do not mention whether or not any of their cases revealed the presence of calcification.

The material selected for this study comprises a group of 11 cases of calcification of the abdominal aorta. A study of them points to the fact that degenerative changes in the abdominal aorta may at times play a significant rôle in the production of gastro-intestinal symptoms. Although the number of instances recorded in the literature are but few, nevertheless one must be on the lookout for this condition, especially in those cases with vague digestive disturbances occurring between the fifth and seventh decades of life.

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It is of interest to note that in this group of cases the finding of calcification of the abdominal aorta was accidental. Because of the complaint of backache, roentgenograms were made of the lumbar spine, and in these films calcification of the abdominal aorta could be clearly seen. In the anteroposterior view no clue of the condition, as a rule, is disclosed. In the present series of cases only one revealed the presence of calcification of the aorta when viewed from the latter position; this is shown in Figure 3. On the other hand, the lateral view clearly demonstrated the calcification in every instance. It seemed of interest to determine whether in addition to the calcification of the abdominal portion of the aorta, the arch of the aorta was likewise involved in this process. In seven cases upon whom teleoroentgenographic studies were made of the chest, in only one instance was calcification of the aortic arch observed. However, calcareous plaques were noted in the lower thoracic aorta in only four instances. These were observed on the lumbar spine films which included part of the lower thoracic area. A lateral view of the entire thoracic area was made in two instances in this series and no evidence of calcification of the thoracic aorta was observed. The deposition of calcium plaques along the abdominal aorta may involve either a small portion or the entire vessel. Occasionally the calcification may be noted to extend as far down as both iliac vessels.

According to Bordet (3), change in the opacity of the aorta is the earliest sign of aortitis, preceding even subjective symptoms. Many factors predispose to this condition. Arteriosclerosis was the most predominant factor in our series of cases, occurring in all instances. In the majority of these cases there were likewise evidences

Fig. 1. A lateral view of the lumbar area, illustrating calcification of the abdominal aorta.

Fig. 2. Another case of calcification of the wall of the abdominal aorta is shown in the lateral view.

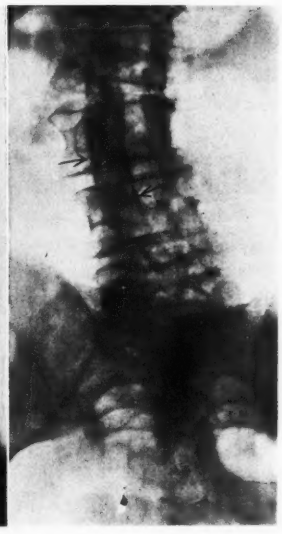

Fig. 3. Same case as shown in Figure 2, demonstrating the calcified aorta in the anteroposterior position.

of cardiac pathology. It is well recognized, however, that the following conditions which predispose to arteriosclerosis are likewise present in calcification: advanced age, syphilis, alcoholism, gouty diathesis, nicotinism, and diabetes. Syphilis must play but a minor rôle in its production, inasmuch as not a single positive Wassermann reaction was noted in ten cases in which this test was performed: in two instances diabetes was present. Advanced age resulting in senile calcification as a predisposing factor plays an important rôle, since the condition is mostly observed between the fifth and seventh decades.

Physiologic Mechanism in the Production of Gastro-intestinal Symptoms.—As the condition affects the wall of the abdominal aorta, transforming a collapsible vessel into a rigid one, certain changes in the circulation of the gastro-intestinal organs must occur which interfere with its normal physiologic function. These changes are instrumental in the production of certain digestive disturbances. Gutmann and Routier (2) consider the digestive variations as related to the arterial pressure and state: "After meals the arterial pressure undergoes three changes: first, an early increase (immediate hypertension), from 15 to 75 minutes later hypotension, and from two to three hours later another hypertensive phase, which is more intense." Many theories have been suggested to explain the occurrence of pain in abdominal aortic affections. According to Potain (4), Teissier (5), and Carriere (6), this is due to an ischemia of the arteries which provokes gastric intermittent claudication. Pal (7) describes this phenomenon as due to vascular crises; Loeper (8) to a neuritis of the solar plexus.

In this series of cases there were five males and six females, the ages ranging between 50 and 75 years. Table I presents our cases arranged according to sex and age. This table discloses that sex is not a factor in this condition. The ages ranged between the fifth and seventh decades, the majority occurring in the sixth and seventh.

Cardio-vascular Changes.—It must be emphasized again that calcification of the

abdominal aorta occurs in the arteriorsclerotic period of life. Arteriosclerosis was present in every instance in this series of cases. Cardiac disease was also a prominent factor, as it occurred to some degree in most of our cases. Mobility and palpability of the abdominal aorta were not detected except in one instance in which pulsations were distinctly palpable. According to Gutmann and Routier (2), auscultation over the abdominal aorta may reveal a systolic murmur quite different from the systolic sound normally perceived, and they attach considerable importance to this sign in abdominal aortitis. Changes in the femoral pulse were not especially noted in our cases, but Gutmann and Routier record some changes in the femoral pulse in aortitis due to changes in the wall of the vessel, resulting in a more rapid flow. Abnormal circulatory manifestations in the abdominal organs must occur as a result of this condition, due to loss of expansibility and contractility of the wall of the aorta. The blood pressure in this group of cases varied considerably.

The rôle which calcification of the abdominal aorta plays in disturbance of the digestive tract is a variable one, inasmuch as there is not always convincing evidence at hand to demonstrate that the change in the aorta is the primary etiologic factor in the production of symptoms. A true clinical picture of the condition is not readily discernible, the symptoms often being of a vague character. There are no characteristic symptoms or group of symptoms which are diagnostic of the condition. Although the diagnosis of calcification of the abdominal aorta is quite simple by means of the roentgen-ray study, its interpretation as a causative factor of gastro-intestinal disturbances is by no means as clear. There can be no question, however, but that this condition may be responsible for many abdominal disturbances, and increasing importance must be attached to this finding when no other organic lesion can be detected to account for the digestive symptoms. An example of a case is presented to illustrate the gastro-intestinal manifestations encountered in this affection.

R. L., aged 58, female, first visited the Sinai Hospital eleven years ago, with the complaint of indigestion. The symptoms were those of fullness, distention, belching, sour regurgitation, constipation, and vertigo. One year later, she developed a constant epigastric pain, which increased following meals. In addition to the pain, the other symptoms described above continued without relief. A gastro-intestinal roentgen investigation proved negative. An Ewald test meal revealed a normal gastric content (free acid 20, total acid 40). Her blood pressure at this time was 128/66. A year later she began to complain of severe backache, which was especially pronounced on movement. Another Ewald test meal, examined two years later, still revealed a normal gastric content (free acid 19, total acid 46). Her backache and digestive symptoms persisted up to this year (1933), when an x-ray examination of the lumbar area revealed the presence of marked calcification of the abdominal aorta. This examination also presented evidence of slight hypertrophic changes of the lumbar vertebræ. It must be pointed out that it is most difficult to establish the fact that these symptoms are due to calcification of the abdominal aorta, but since no other gastro-intestinal lesion could be found to produce these symptoms, it is reasonable to consider the possibility of calcification as a possible etiologic factor.

In a survey of this series of 11 cases, the gastro-intestinal manifestations were of striking interest. In three instances the digestive symptoms were of minor import, the symptoms varying from mild to severe. Pain in the abdomen and back was the most prominent symptom, and was often of an encircling, girdle, or constricting type, radiating from the abdomen to the back and reversely, frequently becoming localized in the epigastrium. Moderate or severe pain occurred in six instances of this series, while in five there was some abdominal distress but no actual pain.

On the other hand, abdominal soreness and tenderness occurred in seven cases. Gutmann and Routier observed that an early discomfort consisting of a sensation of heaviness and tension, with pain coming on three or four hours later, prevailed in his study of the digestive symptoms. In this series of cases the symptoms in some instances resembled those of ulceration, which were relieved temporarily by soda. However, the usual relation of food and the periodicity of the symptoms was not observed. Vomiting occurred in three instances, but in none was there any hemorrhage. Constipation was found in eight cases. In one, diarrhea was a prominent symptom and in two the bowel functioned normally. The appetite remained good in seven cases, while in four it was poor. In three instances acid regurgitation was observed and in six abdominal fullness and distention were noted. Loss of weight occurred in all instances of this series. Backache was likewise a common complaint. The physical examination revealed a generalized arteriosclerosis, with varying degrees of cardiac involvement. The abdomen presented evidences of tenderness and soreness on pressure. In thin individuals, the hard tubular aorta may be palpated and pulsations felt. Hemorrhoids were observed in three of our cases.

Roentgen Examination.—Gastro - intestinal roentgen examinations were performed in five cases of this series, of which three were found to be entirely normal. In one, a penetrating gastric ulcer was observed and in another a moderate duodenal stasis. It is of interest to note that in two cases in which the roentgen examination revealed a normal stomach, ulcer symptoms were quite prominent. In one case, carcinoma of the transverse colon was found, confirmed by operation. The roentgen ray also revealed evidence of enlargement of the heart in three instances and dilatation of the aorta in three cases.

During the routine roentgen examination of the lumbar area, it is especially important to include a lateral view. In this position evidence of calcification of the abdominal aorta may be best visualized. The anteroposterior position obscures the aorta in most instances due to overshadowing of the vertebræ; on the other hand, the anteroposterior view will often reveal the presence of calcification of the iliac vessels. The roentgen diagnosis is made by the presence of calcareous plaques along the course of the abdominal aorta, as it descends along the vertebral column, anterior to the bodies of the lumbar spine. The plaques are of different lengths and thicknesses, of flaky appearance, and are irregularly placed along the margins of the

TABLE I.—IMPORTANT GASTRO-INTESTINAL FINDINGS OF 11 CASES OF CALCIFICATION OF THE ABDOMINAL AORTA

Case	Sex	Age	Pain	Abdominal Tenderness	Vomiting	Fullness and Distention	Appetite	Sour Regurgitation	Constipation	Diarrhea	Associated Gastro-intestinal Conditions	Backache	Loss of Weight	Hemorrhoids
1	M	50	+	+	+	+	+	+	0	+	Ulcer	+	+	0
2	M	60	0	+	0	+	+	0	0	0	Gallstones	+	+	0
3	F	64	+	+	0	0	+	0	0	0		+	+	0
4	F	58	+	+	0	+	0	+	+	0		+	+	0
5	F	70	+	0	0	+	0	+	+	0		+	+	0
6	F	73	0	+	0	+	+	0	+	0	Duodenal Stasis	+	+	0
7	M	75	0	0	0	0	+	0	+	0		+	+	+
8	F	55	+	+	+	0	0	0	+	0		+	+	+
9	M	66	0	0	0	0	+	0	+	0		+	+	+
10	M	55	0	0	0	0	0	0	+	0		+	+	0
11	F	65	+	+	+	+	+	0	+	+	Carcinoma Colon, Gallstones	+	+	0

aorta. The caliber of the aorta becomes quite visible.

Hypertrophic changes in the lumbar vertebræ of varying degrees were observed in six instances of our series.

SUMMARY

In all obscure cases of abdominal discomfort and backache, with vague gastrointestinal symptoms which occur between the fifth and seventh decades, the possibility of the presence of changes in the abdominal aorta should be carefully investigated. Calcification of the abdominal aorta is of sufficient clinical importance to be considered as not only an etiologic factor in the production of lumbar pain, but also as a factor in the etiology of digestive symptoms. The roentgen-ray examination of the lumbar area offers the best means of investigation in the diagnosis of calcification of the abdominal aorta.

Many thanks are due to Dr. Alfred Ullman, who kindly permitted me to use this material. To Dr. Julius Friedenwald, I am deeply grateful for his many suggestions in the preparation of this paper.

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AN ILLUSTRATIVE CASE OF SYRINGOMYELIA TREATED WITH ROENTGEN RAYS

WITH GENERAL DISCUSSION OF THE EFFECT OF RADIATION UPON THIS DISEASE[1]

By HERMAN FRIED, M.D., *New York City*

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THE use of radiation in the treatment of various neurologic conditions has proved to be a valuable therapeutic agent, but the most strikingly favorable results apparently occur in syringomyelia. Within the past decade this mode of treatment has become the choice therapeutic procedure of this distressing disease. Syringomyelia is particularly suitable for roentgen therapy because the pathologic structure of this disease is highly responsive to the action of the rays (1).

PATHOLOGY

The pathologic picture is essentially one of gliosis followed by the formation of a cavity or cavities in the substance of the cord. The glial tissue surrounding the cavity varies in thickness not only in different cases but also at different levels of the same case. The mode of production is not very definite, but the prevailing theory is that the pathologic process is essentially of neuroglial tissue. In short, it is a slowly growing or proliferating process of glia cells and fibers. This is followed by softening of the overgrown newly formed tissue, which consists of fibrils with a few nuclei. The tissue soon begins to stain badly, particularly around the few blood vessels which it contains, and is transformed into a homogeneous rarefied structure. Crevices appear within the area which gradually form into cavities. The cause of this central gliosis is not known; some believe that it is due to a developmental defect or to the persistence of embryonal tissue which later acquires the power of pathologic growth.

From the standpoint of radiotherapy all productive or proliferating tissues, whether inflammatory or not, are radiosensitive (2 and 3). The effectiveness of radiation in syringomyelia is brought about by the destructive action of the rays upon the growing glious tissue. However, in order to obtain the best results it is necessary that the patient should receive the treatment sufficiently early in the course of the disease, before the destructive process has set in, namely, before cavity formation takes place.

This brings us to the question of regeneration of nervous tissue. In discussing this subject we must forbear the claim that radiation can regenerate or reconstruct nerve tissue, despite the fact that this often militates to some extent against the use of roentgen therapy of this disease. Those who oppose radiation in syringomyelia claim that, whereas it is admitted that the condition is a destructive process and that the rays have no power to regenerate nerve tissue, it seems absurd to claim that the use of x-rays can bring about a cure or relief in this affection. Our answer to their objection is simple. As stated above, we still refuse to claim that roentgen rays can reconstruct or regenerate nerve tissue. Nor do we claim that we can always completely cure a case of syringomyelia without residual sequelæ.

Radiation, however, can halt the inflammatory process of nerve cells and fibers in the same manner that it does in any other inflammation. This may bring about a partial or even complete recovery, depending upon the severity of the inflammation as well as upon the extent of the destructive damage which has already

[1] Read before the Clinical Society, Hospital for Joint Diseases, March 6, 1934.

been done to the spinal cord before irradiation had been instituted. Furthermore, if the condition has already reached the destructive stage, radiation can also interfere with the process, and in this way it is possible to preserve the residual function of the cord which has been retained in the tissue. Before presenting the case let us briefly review the clinical side of this disease.

Syringomyelia can be recognized by the following three groups of symptoms:

(1) A progressive muscular atrophy of the upper extremities with fibrillary twitchings.

(2) Sensory disturbances which take the form of syringomyelic dissociation or posterior-horn type dissociation of sensibility.

(3) Trophic and vasomotor disturbances which include paronychia, anomalies of sweat secretions, osteo-arthropathies, fissures, ulcers, and gangrene (4).

REPORT OF CASE

The patient was first seen in August, 1932, at which time he presented a history of six months' duration. He had had a cold and soon after felt a weakness in both hands, being unable to cut bread or button his clothing. This weakness continued for several months, and then improved slightly. He worked as a counterman in a restaurant; was never exposed to metal poisoning; had no history of alcohol or syphilis, and did not complain of paresthesias.

At his first examination his hands showed a symmetrical atrophy of the thenar and hypothenar eminences, and of the space between the first and second metacarpal bones. Also, there was a partial flexion contracture of all the interphalangeal joints which gave a claw-like appearance to the hands. There was atrophy of all interossei. A bilateral coarse tremor and marked weakness of both hands were present. A slight thickening of the subcutaneous tissue of the hands was present, but there was no wrist drop. Reflexes could not be elicited at all in the upper extremities. Knee-jerks were equal and somewhat hyperactive. Sensation to pinprick was at first unimpaired. He had a slight difficulty in speech, and some tremor of the tongue. Sensory impairment could not be elicited early in the disease, but later, on April 15, 1933, areas of analgesia and thermoanesthesia were found in the upper extremities, the higher segments of the trunk, as well as the neck and shoulders. The diagnosis of syringomyelia was made.

The case was referred to our department for radiotherapy. Roentgentherapy was administered at weekly intervals. The factors of radiation were as follows: 150 K.V.; 5 ma.; filtration, 4 Al; focal distance, 40 centimeters. One-third of an erythema dose was given weekly for each area. The field for irradiation consisted of the entire cervical and upper dorsal spine.

After six weeks, sensory disturbances were ameliorated. Impaired muscular function and tone were markedly improved after six treatments, but muscle atrophies in the upper extremities were not improved as far as the apparent volume of muscle was concerned. He practically lost his tremor and was able to resume work. The color of the skin of his hands, which had been reddish, became almost normal. In short, both objective and subjective symptoms improved, and while his pain conduction fibers are evidently normal, he still has some impairment in the conduction of the temperature fibers.

THE EFFECT OF RADIATION IN SYRINGOMYELIA

This case presented the following interesting clinical and radiologic features:

(1) It is commonly known to radiologists that subjective complaints of coldness, numbness, and tingling sensations will usually disappear in a short time under the influence of roentgen rays. When no definite improvement takes place by the end of the first series of treatments, a

favorable effect can hardly be expected from further irradiation. The amelioration of these subjective symptoms were, therefore, highly satisfying in this case because they indirectly indicated a favorable prognosis.

(2) The segmental pain and temperature fibers are generally the first to be affected, and as a rule there is an early loss of sensitivity to pain and temperature sensation. In this case these sensory disturbances appeared later than all other symptoms of syringomyelia, thus making the diagnosis difficult, which incidentally delayed radiation treatment.

(3) Another striking feature of the case was the extraordinary slow progress of the disease. It took two years before some pathognomonic signs and symptoms of syringomyelia came to the front.

(4) Irradiation will restore the pain and temperature sensibility in all cases except when the duration of the disease was unduly prolonged before the treatment was commenced. Nevertheless this does not always apply to disturbances in temperature sensation. They sometimes will persist even after two or more series of treatments have been administered.

Referring to the illustrative case of this paper, we find that after six treatments the patient began to improve. His sensory disturbances, as far as the pain fibers were concerned, were much better and their function was gradually completely restored: This was not the case with the temperature fibers; their restoration was delayed and despite the fact that almost all other signs and symptoms have disappeared, except a slight disability of his right hand and fingers (which does not at all interfere with his work), we cannot claim complete restoration of the temperature sensibility.

Giese and Ossinskaja (5) report eight patients out of a group of 128 in whom the temperature sensibility remained disturbed after pain sensibility had otherwise become normal. Other observers also claim that pain sensations are more completely and readily restored than the temperature sensibility (6).

(5) From the standpoint of clinical material and clinical demonstration, this case was ideal. His hands were full of cuts, bruises, burns, and scars. These injuries were sustained because he was unaware of the loss of sensation, and therefore scalded or injured his hands without knowing it. The sensory dissociation made its advent insidiously, it being unnoticed by the patient until one day while bathing he discovered that he could detect cold and heat upon some parts of the skin and not on others.

(6) Muscular atrophy is a common clinical feature of this disease. It is entirely dependent upon the amount of pathologic changes that are present in the gray matter. There is a difference of opinion as to the ultimate effect radiation therapy has on muscle, tendon, and cutaneous reflexes. Many believe that radiation has little or no effect; on the other hand, some authors frequently report complete restoration of some reflexes particularly the tendon reflexes of the upper extremities.

Muscle function generally improves and becomes normal in 50 per cent of the cases. Paresis and paralysis of various muscles of the upper extremities are more frequently improved after irradiation than those of the lower extremities. We also obtain similar results in gait, ataxia, and muscle strength. Above all, the bulbar symptoms improve to a relatively greater degree than the motor disturbances of the lower and upper extremities. In our case under discussion, muscular atrophy of both hands and forearms were equally affected, but the muscles of the back were normal. After six treatments the patient was able to return to work. The tremor of the hands gradually improved and the contractures resulting from muscular atrophy became normal (6 and 7).

There are no routine iron-clad rules for the technic of radiation therapy in syringomyelia, as there are none for other conditions. Each case presents different and

peculiar pathologic and clinical characteristics which must be met individually by the radiotherapist. It is, therefore, improper to say that cases of syringomyelia should obtain radiation to the cervical and upper dorsal region of the spine as a routine measure; the better procedure is to localize each lesion of the spinal cord. This largely determines the degree and extent of the inflammatory or destructive process that may be present. In this disease, localization is a great help to the radiologist because it indirectly maps out the proper fields to be irradiated and aids in centering the tube for each area to be treated. If the radiologist has insufficient training in the localization of spinal lesions, it is his duty to call in a neurologist for the purpose of interpreting the topographical relations of the vertebræ to the segment of the spinal cord.

Our knowledge of motor, sensory, reflex, and visceral representations in the single segments of the cord is fairly adequate today to enable us to localize circumscribed lesions that involve the white and gray matter at a definite level. In most of the cases of syringomyelia the sensory disturbances, *viz.*, loss of pain and temperature sensibility, are segmental in distribution. They are caused by inflammation or destruction of the posterior horns of the gray matter of one or several segments.

Let us suppose that we find areas of analgesia and thermo-anesthesia in the upper extremities, the higher segments of the trunk, as well as of the neck and shoulders. This distribution of the insensitive areas shows the type of cases most frequently met with in the larger clinics of New York City. It definitely points to involvement of the cervical and upper dorsal regions of the spinal cord. The author's technic in such cases is as follows:

The field of radiation should include the entire cervical spine, also the dorsal spine as far down as the seventh dorsal vertebra. The size of each field to be 8 × 10 cm., arranged lengthwise close to each other. The factors are 180 K.V., 4 ma., filtration, 0.5 Zn plus 3 Al, focal distance, 40 centimeters. Each field should obtain one-third of an erythema dose at one sitting. The treatment should be administered every other day until each field has obtained 100 per cent of a skin erythema dose. This is followed by an intermission of six weeks, when another series may again be administered in the same manner described above. A third and fourth series may be repeated if necessary after a further intermission of eight weeks between each series.

SYRINGOBULBIA

Cases which are not quite as frequently met with as the ordinary cases of syringomyelia are those that affect the brain stem. This condition is generally known as syringobulbia. The disease affects primarily the medulla and may involve the motor nuclei of the cranial nerves. Very often syringomyelia and syringobulbia are associated. The manifestations of bulbar disease may precede those of spinal involvement, or *vice versa*. Whether the disease ascends from the cord to the brain stem, or descends from the brain stem to the cord is a mooted question. These cases present fibrilations, atrophy, and paresis of the tongue. The palate, uvula, and vocal cords may show similar signs. The sensory disturbances in these patients are found in the region of the trigeminus. Perception of pain and temperature is lost, while other sensations are as a rule unimpaired. In short, the lesions of this condition are primarily in the brain stem, but they are also as frequently present in the cervical spine.

The treatment plan for radiation in cases of syringobulbia is similar in principle and method in every respect to the procedure described for syringomyelia, except that one occipital field and two lateral fields of the head (one on the right and one on the left side over the base of the brain) are irradiated in addition to the fields of the cervical and upper dorsal spine.

In short, radiation can bring about a partial or even a complete recovery depending upon the severity of the inflamma-

tion as well as upon the extent of the destructive damage which has already been done to the spinal cord before irradiation had been instituted.[2]

In the case under discussion, no final diagnosis was made until eight months had passed after the patient presented himself to our clinic for the first time. Before he came to us, he had been under observation in other institutions of this city. In none of them was a definite diagnosis made of his condition. Syringomyelia was suggested by some of the neurologists but this diagnosis had to be excluded because of the inability to establish sensory dissociation. However, something occurred in his condition which changed the entire aspect of the case. On April 15, 1933, which was approximately two years after the initial symptoms of his affection and eight months after he became a patient of our clinic, he clearly and unquestionably showed definite analgesia and thermo-anesthesia, which once and for all confirmed syringomyelic dissociation (8 and 9).

The author therefore is of the opinion that this case ran a parallel course with the one reported by Head and Thompson. In both cases the diagnosis was difficult because of the absence of analgesia, and in both, analgesia did not come to the front until some change occurred in the physical condition of the patient, which interfered with the diagnosis of syringomyelia. In their case it was a co-existent arthropathy; in our case an undetermined condition that hindered the elicitation of sensory dissociation.

There are many causes for the delay of the appearance of sensory disturbances. For instance, the distribution of thermo-anesthesia and analgesia is often found to be irregular. If the progress of the disease is slow, we may find sensory loss in one hand which may be limited above a line encircling the forearm. In the same way, an area including the nose, mouth, and eyes may preserve its sensibility intact, while the surrounding regions are completely insensitive to pain and temperature. Quite often we come across one patch of analgesia and thermo-anesthesia which is separated for a time from another by a healthy area, and coalescence occurring later on. Such and similar conditions, which happen quite frequently (10), are apt to mislead the examiner and throw him off the proper track.

[2] In explanation of the late appearance of sensory disturbances of this patient, the author is of the opinion that this case was similar to the one reported by Head and Thompson. In that case, complete cutaneous analgesia was co-existent with deep hyperalgesia of a painful arthropathy. The lightest pressure produced pain; yet superficial layers of the skin were analgesic to the prick of a pin, when raised from the subcutaneous structures.

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THE INHIBITION OF GROWTH IN POLLEN AND MOLD UNDER X-RAY AND CATHODE RAY EXPOSURE[1]

By C. P. HASKINS *and* C. N. MOORE, *Schenectady, N. Y.*

IT was the purpose of the following investigation to determine, within fairly wide limits, the point at which mature pollen grains, cultured *in vitro*, and mature spores of *Penicillium* become inactivated on exposure to x-rays and high voltage cathode rays. Such a piece of work seemed of interest and desirable for several reasons. So far as known by the authors, no systematic previous work has been undertaken in the x-raying or cathode raying of mature pollen with a view of determining its rate of "dying" and its point of inactivation. Considerable work has been done in the x-raying of mature pollen in the hope of producing mutations, and, while such work does not show promise of yielding nearly as fertile results in the form of genetic aberrations as may be obtained by the irradiation of pollen mother cells previous to the first reduction division, it is of interest that rough working data of permissible limits of exposure under given conditions should be at hand. Again, so far as known by the authors, no comparative work has been done on the resistance of pollen grains and mold spores to x-rays and cathode rays under the same conditions. Such a comparison should be of interest in view of the work which has been done in the x-raying and cathode raying of molds. It seemed worth while to investigate pollen as a biologic material of possible use in quantitative studies of radiation effects. And finally, little work appears to have been done, even with the molds, in the comparative investigation of the energy inputs of different forms of energy at roughly equivalent points of inhibition.

Material Used.—After considerable preliminary work involving a large range of plant material, it was decided to confine the experiments with pollen to that of plants of the family *Liliacæ*, and to work principally with *Lilium longiflorum* because of its availability at all times and the ready germinability of its pollen under a fairly wide range of conditions. Several other species were included in the investigation, however, and found to be essentially similar in behavior. Chief among these were *Lilium speciosum*, *L. regale*, *L. henryi*, and *L. auratum*. Some work was also done with *L. philadelphicum*, *L. canadense*, *L. sulfurum*, and even the triploid day lily *Hemorocallis fulva*, but these species proved less satisfactory and were abandoned.

Spores of a culture of the green-spored mold genus *Penicillium* were used, and proved so ready of culture and so thoroughly satisfactory in germination throughout that it was unnecessary to consider any further material.

Sources and Character of Radiation.—Two sources of x-rays and one of cathode rays were used in this work, so selected that comparisons of inactivation might be made under fairly widely variant conditions.

As a source of soft x-radiation, a line-focus tube with copper target was used, connected to the pumps, and operated from a high tension transformer. It was completely self-rectifying when operated, as it was throughout the work, at 37 K.V. r.m.s. and 20 ma. of current. It was provided with an aluminum window of 0.025 mm. thickness.

The pollen and mold were treated at a focal distance of 5.1 centimeters. The tube output was measured at a focal distance of 41.9 cm., and a current of 10 ma. with a standard Failla radium-compensated measuring instrument. The device, however, was equipped in place of the

[1] Received for publication Oct. 13, 1934.

usual collodion, graphite-coated thimble chamber, which is suitable for use with harder radiation, with a special silk-mesh chamber devised by Dr. Failla, and most kindly lent to us by him, in which the wall and absorption effects of longer radiation are very largely eliminated. It was, therefore, unnecessary to introduce corrections for these factors which should certainly have been introduced with most other types of chambers. The distance factor was extrapolated to the position of the pollen grains and mold spores in accordance with the inverse square law. The procedure was not strictly correct in this case, since with this tube the radiation did not emanate strictly from a point source, but the accuracy of the procedure was well within the limit set by the experimental material itself. The milliamperage factor was also extrapolated to that used, the curve in this case being very nearly reliable. The incident energy input of the tube under experimental conditions, at the point of exposure of the material, was found to be 2.1×10^4 roentgens per minute.

In quality, the x-ray beam from this tube was very nearly monochromatic, by far the greater portion of radiation lying in the regions of the Kα and Kβ lines for copper, respectively 1.537 and 1.389 Ångstroms. The shortest wave length theoretically obtainable at this voltage was in the neighborhood of 0.3355 Å. as calculated from the fundamental quantum relation $Ve = h\nu_{max.}$ as applied by Duane and Hunt.[2]

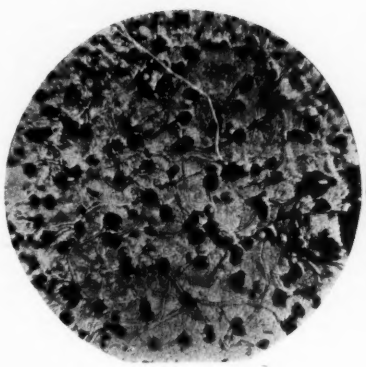

Fig. 1-*A*.

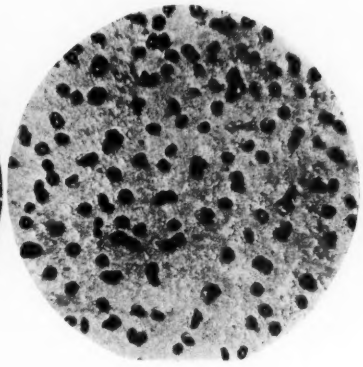

Fig. 1-*B*.

The source of hard radiation used was a standard Victor deep therapy outfit, comprising a high tension transformer with cross-arm mechanical rectifier of the Snook type as the high voltage generator, and a standard Coolidge water-cooled tungsten-target tube, of the thick-walled type. The tube was operated at 200 K.V.P. and 30 ma., the pollen and mold being exposed at a focal distance of 11.4 centimeters. The incident energy input of the tube was measured at the point of exposure of the material with the Failla instrument, the collodion-graphite chamber, which at this voltage exhibits negligible absorption and wall effects, being used. It was necessary to reduce the tube current to 1.5 ma. and to extrapolate to the higher value in order to bring the energy reading within the range of the instrument. The input was found to be 3.0×10^3 roentgens per minute under the conditions of experiment.

The shortest wave length theoretically obtainable at this voltage was 0.062 Å. No metal filter was used, but the glass of the wall interposed a filtering action

[2] Phys. Rev., 1915, **6**, 166.

equivalent to about 0.10 mm. of copper. At 0.70 Å. the intensity of the emergent radiation was only about 0.3 per cent of that impinging on the inner wall surface, as calculated from Compton's 1926 value for the mass absorption coefficient of Cu,[3] and this may be considered the cut-off point. Substantially all of the primary radiation incident was included within these limits. The greatest intensity of radiation lay within the K_α and K_β doublet region for W, between 0.21 and 0.18 Å. The second and third order lines were present, though of greatly diminished intensity, but general radiation at this voltage is very considerable.

A Coolidge single-stage high voltage cathode ray tube, equipped with "Resistol"[4] window, of 0.6 *mil* thickness, connected to the pumps, and operated at 250 K.V.P. and 1.5 ma. was the source of cathode rays. Since the window was air-cooled, it proved more convenient to vary the distance of the experimental material from the tube, the time of exposure being maintained at one second. The material was treated at window distances of 1, $1^1/_4$, $1^1/_2$, $1^3/_4$, 2, $2^1/_4$, $2^1/_2$, $2^3/_4$, and 3 inches.

Several methods may be adopted for the calibration of a high voltage cathode ray tube, as described by Coolidge and Moore,[5] Taylor,[6] Lenard,[7] and others. The method which proved most convenient in the present case was a thermal calibration devised by Daniels and Bussey,[8] which presents the advantage that, in cases such as ours in which the tube window must remain electrically floating, no grounding connection of the reading instrument is necessary. A measurement of the heating effect of the electron stream in calories was made with a copper calorimeter of 7.5 cm. diameter and 0.3 cm. thickness, built as a thin drum from two soldered spinnings. The vessel was equipped with a fine glass capillary and filled with nitrobenzene, which acted at once as the heat-absorbing medium and the temperature indicator. The capillary was fitted with a scale, and readings of the meniscus rise made with a telescope mounted at a safe distance. Immediately after the completion of readings, which consisted usually of ten trials, the calorimeter was calibrated in water, the volume of water remaining constant (to avoid a change of pressure on the calorimeter walls, the device being surprisingly sensitive) and

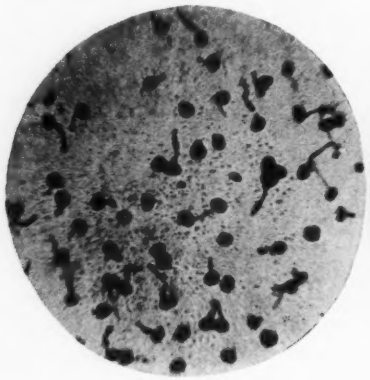

Fig. 2-*A*.

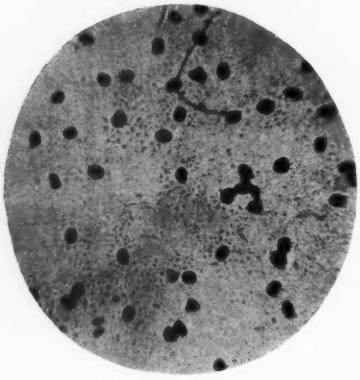

Fig. 2-*B*.

[3] Compton, X-rays and Electrons, D. Van Norstrand Co., 1926.

[4] A chrome-nickel steel.

[5] Coolidge, W. D., and Moore, C. N.: G. E. Rev., August, 1932, **35**, 413–417.

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the temperature gradually falling through a small range. The rise of nitrobenzene in the capillary was a marked one, amounting often to five or more thermometric scale divisions.

Once the incident energy of the cathode beam had been determined in calories per unit area it was readily convertible to roentgens, using Gaertner's[9] value for the ionization potential of air in electron volts and an electron volt-calorie equivalence factor derived from Crowther's[10] factor for the erg in electron volts. Such a procedure does not give the correct order of magnitude of the ratio of energy inputs of the two sources, however, since the copper calorimeter, by virtue of the fact that it absorbs an extremely high percentage of all incident electrons, is in reality measuring the energy derived from a cathode beam of given cross-section and infinite extent, while the ionization chamber measures the energy similarly derived from an x-ray beam of given cross-section, but, by definition of the roentgen, also of finite length (1 centimeter). We may roughly correct for this situation in this fashion. Let us calculate the voltage drop of a single electron at the calorimeter face in traversing a one-centimeter layer of air and determine what percentage it is of the total drop. Then, since the calorimeter completely stops every electron striking its face (an assumption justified for this work), the true value of the energy of the cathode beam in terms of roentgens will be its measured energy, converted to roentgens on the basis of the derived calorie-roentgen equivalence factor already determined, multiplied by this factor—a procedure which also involves the assumption that electron velocity in a cross-sectional area of this cathode beam is uniform. Using the J. J. Thompson formula[11] for the voltage drop of a single electron

$$V_0^2 - V_x^2 = Kdr$$

when K = electron mass abs. coefficient
d = density of matter traversed
r = thickness of layer traversed

the electron velocity at the outer face of the calorimeter was calculated at each experimental point, the first portion of the calculation accounting for the tube window, the second for the air layer. The voltage drop for an electron at this velocity through one centimeter of air was next determined. The ratio of this drop to the total was calculated and applied to the energy derived at each distance on the conversion basis. Proceeding in this fashion, determinations were made at distances from the tube window of 1, 2, $2^1/_2$, and 3 inches, the output being found to be, respectively, 9.0×10^4, 4.0×10^4, 1.6×10^4, and 1.1×10^4 roentgens per second. These values are probably low, due to the fact that the assumptions mentioned are not strictly valid.

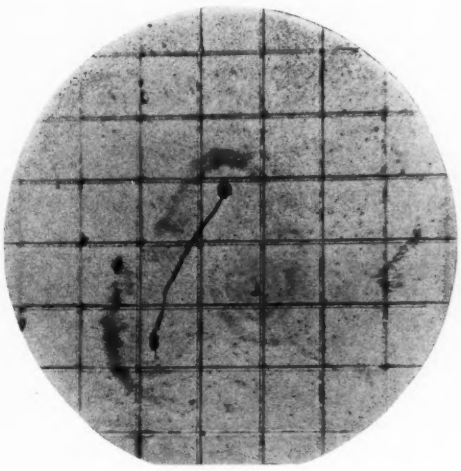

Fig. 3.

The accuracy of the calibration procedure used with cathode rays is probably the lowest of the three sources. Errors of reading in the calorimeter and errors introduced by changing conditions within the copper cell itself, though minimized

[9] Gaertner, O.: Ann. d. Physik., June 7, 1929, **2**, 94–122.

[10] Crowther, J. A.: British Jour. Rad., 1929, **2**, 175–187.
Bond, W. N.: Phil. Mag., 1926, **6**, 401–422.

[11] Conduction of Electricity through Gases, p. 378.

by averaging a number of readings, were undoubtedly present, and cathode-ray scattering was unquestionably a vitiating factor. The measurements, however, are considered to be within the accuracy required for present purposes.

CULTURE AND EXPOSURE OF POLLEN AND MOLD

The method of pollen culture was essentially that of Jost,[12] which has since been used with good success by a large number of other workers. Agar cultures of 2 per cent concentration by weight were made up with distilled water. In preliminary work, samples containing 5, 10, and 15 per cent by weight of cane sugar were used, but it was found desirable to eliminate this variable, and only 5 per cent cultures were used in the final work. Drops of culture medium were flowed onto 7.5 × 2.5 cm. plain slides, or, in some cases, onto 2.5 × 2.5 cm. glass squares, and allowed to set. The pollen was sowed immediately before exposure to radiation. In one series of runs the agar was coated with a "sterile yeast" solution, prepared according to the directions of Brink[13] and carefully dried before inoculation of pollen. This was found, in conformity to Brink's work, to bring about a longer tube development and a higher total germination percentage, as indicated in the accompanying figures, but did not markedly affect the shape of the survival curve.

A simple and rather thoroughly satisfactory method was developed for the sowing of the pollen, which eliminated, on the one hand, the clumping which results from dry sowing and which, because of the limited penetration of cathode rays, should be avoided, and on the other the limited and thoroughly erratic germination which frequently results from sowing on the surface of an evaporable liquid. A small clump of pollen was allowed to spread on a drop of water placed on the agar until a uniform, nearly equidistant, spacing of the grains was obtained. The water drop was then removed with filter paper and the slide quickly inverted in a desiccator over $CaCl_2$ and allowed to remain in this position until the agar was sufficiently hard so that each grain did not sink into a pit. The slide was then brought to its normal position, irradiated, and cultured in a humid chamber. One or two runs were made in a constant temperature incubator, but this proved an unnecessary refinement, since the rate of growth was not measured. A period of eighteen hours at room temperature was allowed for development, which proved sufficient to give good growth of pollen tubes without permitting the growth of molds. In a few cases, pollen after sowing was stored in a refrigerator in a moist atmosphere at about 4° C. for several hours before irradiation and culture. This proved permissible, since the pollen showed no visible tendency to germinate under these conditions, but was of undiminished vitality when brought to room temperature. In the majority of cases, pollen was sown from anthers plucked directly from young flowers. In the few instances where it became necessary to harvest pollen, anthers were stored over $CaCl_2$ in a refrigerator during the intervening period—procedure found quite satisfactory by Stout[14] and Holman and Brubacher.[15]

Several means were adopted for convenience in counting the germinated cells. The best of these proved to be a modified balopticon, in which the image of the pollen, under approximately 50 diameters magnification, could be thrown on a cross-ruled screen and examined with both eyes uncovered through a viewing hood. A record of count of more than 20,000 grains was made.

The procedure adopted in the case of mold spores differed but slightly from that used with pollen. In the case of low voltage x-rays and cathode rays, mold

[12] Jost, L.: Ber. deutsch. Bot. Ges., 1907, **23**, 504–515.

[13] Brink, R. A.: Am. Jour. 1924, Bot., 1924, **11**, 283–294.

[14] Stout, A. B.: Unpublished communication.

[15] Holman, R. M., and Brubacher, F.: Univ. Cal. Pub. Bot., 1926, **13** (10), 179–204.

spores were pressed from sporangia borne by mycelia usually less than forty-eight hours old onto clean 7.5 × 2.5 cm. glass slides. The slides were irradiated, and the spores clinging to them were then sown dry upon sterile cultures of prune agar. They were then cultured in moist sterile chambers at 30° C. for from twenty-four to thirty hours. In the case of high voltage x-rays, spores were sown on agar on 2.5 × 2.5 cm. glass squares before irradiation. The elevated and constant temperature so accelerated development as to prove desirable. Dry sowings gave satisfactory results, and it was found better in the present case to examine the spores directly with the microscope in counting. Both spores and pollen grains were occasionally stained with I to facilitate counts. A record of count of 40,000 spores was made.

The methods of exposure to radiation were essentially the same for pollen and molds. In the case of the high voltage x-ray tube and the cathode-ray tube, the area exposed was many times that occupied by the sample, so that moderate evenness of radiation intensity throughout the sample was assured. With the low voltage tube, however, the irradiated area was of the same order of magnitude as that occupied by the sample. The position of the sample was carefully checked with a fluorescent screen in this case, and an additional check was afforded by the blackening of the glass over the exposed area, forming a sharply defined spot. In the case of the low voltage x-ray and the cathode-ray tubes the samples were exposed directly to the beams. The longer times required for inhibition with the high voltage source necessitated that the slides be enclosed in glass Petri dishes to prevent their drying. The measurement of incident energy in the latter case was made under a Petri dish cover, thus including such absorption and scattering as might take place there.

RESULTS

The results of each experiment were expressed in terms of the survival ratio as defined by Wyckoff,[16] the ratio of the percentage of grain or spores showing development to those showing similar development in the controls. A control culture was made for each series of runs. A large number of preliminary runs was made, followed by a relatively small number of final tests, when the approximate "lethal limit" was established and the technic of irradiation and culture properly developed.

SOFT X-RAYS

I. *Molds.*—Four series of final experiments, involving 7,800 spores, were made with mold, yielding the following results:

TABLE I

Test	2 min.	4 min.	6 min.	8 min.	10 min.	12 min.	14 min.
1	0.80	0.40	0.16	0.16	0.12	0.05	0.04
2	0.80	0.57	0.38	0.24	0.05	0.01	0.04
3	0.86	0.54	0.19	0.21	0.11	0.05	0.06
4	0.93	0.37	0.18	0.26	0.15	0.01	0.03
Average	0.85	0.47	0.23	0.22	0.11	0.03	0.04

II. *Pollen.*—Five series of final experiments, involving 2,040 counted pollen grains, were made with soft x-rays, at exposures of 4, 6, 8, 10, 12, and 14 minutes, as shown in Table II.

TABLE II

Test	4 min.	6 min.	8 min.	10 min.	12 min.	14 min.
1	0.78	0.91	0.27	0.41	0.15	0.00
2	1.40	0.52	0.52	0.00	0.05	0.00
3	0.29	0.12	0.00	0.14	0.22	0.00
4	0.41	1.50	1.10	0.78	0.41	0.00
5	2.80	1.80	1.90	1.50	0.67	0.17
Average	1.10	0.97	0.74	0.57	0.30	0.03

HARD X-RAYS

Molds.—Five series of final tests were made with hard x-rays, the number of counted spores being 13,000. Exposures were made with a time increment of ten minutes. The energy increment was thus 3.0×10^4 roentgens, as against an increment of 4.2×10^4 roentgens at two-minute intervals with soft radiation. The rate of inactivation, however, proved much slower, so that exposures of 20, 30, 40,

[16] Wyckoff, R. W. G.: Jour. Exp. Med., Nov. 1, 1930, **52**, 769–780.

50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, and 170 minutes were made. In order to reduce the number of recorded trials, they were averaged in pairs, with the results shown in Table III.

Pollen.—The procedure followed with pollen was the same as that with molds, except for differences in manipulation already indicated. It was decided, however, to omit the last two exposure groups given in mold in which, as with mold, negligible germination would take place.

CATHODE RAYS

Mold.—Five runs were made with unfiltered cathode rays, involving a count of 9,000 spores, the results being as shown in Table V.

Pollen.—Two sets of runs were made with cathode rays, involving 5,283 grains. The first, including three sets of experiments, was done, as in the previous cases, only with pollen of *L. longiflorum*, and from this the energy value of inactivation used in comparison with the inactivating energy dose from other sources was taken. In the second series one of the runs of the first group is compared with runs of pollen of three other species under the same conditions. The results were quite closely similar. The inactivation range was such that exposures were made between distances of one inch and three

TABLE III

Test	Min. 20–30	Min. 40–50	Min. 60–70	Min. 80–90	Min. 100–110	Min. 120–130	Min. 140–150	Min. 160–170
1	0.93	0.80	0.64	0.54	0.43	0.21	0.26	0.00
2	0.87	0.90	0.49	0.56	0.35	0.30	0.05	0.00
3	0.87	0.66	0.18	0.07	0.01	0.00	0.00	0.00
4	0.79	0.78	0.44	0.38	0.26	0.15	0.03	0.04
5	0.85	0.76	0.50	0.46	0.14	0.07	0.00	0.02
Average	0.86	0.78	0.45	0.40	0.24	0.15	0.07	0.01

TABLE IV

Test	Min. 20–30	Min. 40–50	Min. 60–70	Min. 80–90	Min. 100–110	Min. 120–130
1	0.37	1.20	1.00	0.49	0.30	0.41
2	0.88	1.10	1.10	0.93	0.96	0.00
3	0.39	0.12	0.10	0.00	0.02	0.07
4	0.32	0.24	0.26	0.01	0.01	0.01 (120 only)
5	0.51	0.63	0.28	0.08	0.10	0.42 (120 only)
Average	0.49	0.66	0.55	0.30	0.28	0.18

TABLE V

Test	2 in.	2 1/4 in.	2 1/2 in.	2 3/4 in.	3 in.	3 1/4 in.	3 1/2 in.	3 3/4 in.	4 in.
1	0.00	0.02	0.03	0.13	0.40	1.00	1.00	0.92	1.00
2	0.00	0.00	0.05	0.00	0.30	0.84	0.85	0.91	0.89
3	0.00	0.00	0.00	0.00	0.26	0.56	0.76	0.78	0.90
4	0.05	0.05	0.08	0.25	0.38	0.17	0.74	0.68	0.85
5	0.03	0.47	0.51	0.61	0.91	0.82	0.87	0.90	0.87
Average	0.02	0.11	0.13	0.20	0.45	0.68	0.84	0.84	0.90

TABLE VI

Test	1 in.	1 1/4 in.	1 1/2 in.	1 3/4 in.	2 in.	2 1/4 in.	2 1/2 in.	2 3/4 in.	3 in.
1	0.00	0.00	0.01	0.01	0.00	0.02	0.00	0.05	0.32
2	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.07
3	0.00	0.00	0.00	0.01	0.50	0.39	0.82	1.00	1.11
Average	0.00	0.00	0.00	0.01	0.16	0.14	0.29	0.36	0.50
Species	1 in.	1 1/4 in.	1 1/2 in.	1 3/4 in.	2 in.	2 1/4 in.	2 1/2 in.	2 3/4 in.	3 in.
L. longiflorum	0.00	0.00	0.00	0.01	0.50	0.39	0.82	1.00	1.11
L. henryi	0.00	0.00	0.00	0.03	0.79	0.89	1.11	0.70	1.00
L. auratum	0.00	0.00	0.00	0.01	0.87	0.84	1.11	0.72	1.00
L. speciosum	0.00	0.00	0.00	0.01	0.85	0.55	0.44	1.00	1.00
Average	0.00	0.00	0.00	0.02	0.75	0.67	0.87	0.86	1.04

inches from the window instead of between two and four inches as with the mold spores, the increment being, as before, one-quarter of an inch.

DISCUSSION

It seemed possible that the inactivation with x-rays or cathode rays might be due to other things than the primary beam, or the x-rays produced or electrons released within the tissues of the material. Secondary x-rays from the glass of the microscope slides, chemical changes brought about within the irradiated agar or even at the glass surface might well be considered vitiating factors. To check these points, agar samples were made up on glass slides, and after x-raying at the lower voltage, were sown with untreated pollen. Germination was perfectly normal. Agar samples were then made up on strips of cellulose acetate, inoculated with pollen, and rayed. The rate of inhibition was not appreciably changed, although the secondary radiation from the acetate would be supposed to be of a different character from that of the glass. The authors were satisfied that the order of magnitude of errors resulting from such effects was not such as to interfere with their results.

It is to be seen that mature pollen of the Easter lily exhibits a remarkable tolerance for x-rays and cathode rays, which is shared by other species in the case of the latter. A similar tolerance is evident with the molds. Thus, if the number of roentgens of incident energy be tabulated in runs for pollen grains and mold spores for the three energy sources in which the survival ratio fell nearest to 0.5, the result is as shown in Table VII. It will be noticed that, for the two materials, there is rather close correspondence in the energy input required to reduce the survival ratio to approximately the same figure.

It is interesting to read Table VII in the other direction, and consider, for the same material, the comparative energy required to reduce the survival ratio to approximately the same figure for the three energy sources. It will be seen that this input is greater with hard x-rays than with soft x-rays by a factor of about 2.1 for mold and about 6 for pollen. This deviation, although in the direction which might be expected, is probably of no significance in the case of mold, and certainly of none, for reasons later to be mentioned, in the case of pollen. The same is true for cathode rays.

To make certain that cathode-ray particles, known to discharge a very large proportion of their energy near the end of their paths, were not passing through the cell tissue and into the material behind it in quantity, the following experiment was undertaken. If this were true, it should be possible to lower the mean velocity of electrons in the cathode beam to the point where they would be absorbed in the cell tissue. If exposures be made with increasing filter thickness, it should be possible, at some point between normal killing and complete shielding, to produce a marked increase in effectiveness of the treatment, corresponding to a critical electron velocity. This experiment was carried out. Mold spores were exposed to the cathode beam in the usual fashion, at distances of 1, 2, 3, and 4 inches, in groups screened with one, two, and three "Resistol" windows of 0.6 *mil* thickness, exactly similar to that used on the tube itself. A control was run with each group, and survival ratios, obtained as usual, were as shown in Table VIII.

It will be seen that, although the survival ratio for each exposure increases progressively with increased shielding, there is in every case a smooth and regular decrease of survival ratio with increase of exposure. In no case is there any indi-

TABLE VII

Material	Soft X-ray		Hard X-rays		Cathode rays	
	S.R.	Energy input	S.R.	Energy input	S.R.	Energy input
Mold	0.47	8.4×10^4 r	0.45	$1.8\text{–}2.1 \times 10^5$ r	0.45	1.1×10^4 r
Pollen	0.57	3.0×10^4 r	0.55	$1.8\text{–}2.1 \times 10^5$ r	0.50	1.1×10^4 r

TABLE VIII

Trial	1 in.	2 in.	3 in.	4 in.	Control
			1 Window		
1	0.00	0.00	0.76	1.00	1.00
2	0.00	0.02	0.75	0.95	1.00
3	0.00	0.03	0.57	0.82	1.00
4	0.00	0.00	0.56	0.71	1.00
5	0.00	0.00	0.89	1.00	1.00
Average	0.00	0.01	0.71	0.90	1.00
			2 Windows		
1	0.00	0.67	1.00	1.00	1.00
2	0.42	0.96	1.00	1.00	1.00
3	0.00	0.64	0.87	1.00	1.00
4	0.00	0.78	1.00	1.00	1.00
5	0.00	0.50	0.76	1.00	1.00
Average	0.08	0.71	0.93	1.00	1.00
			3 Windows		
1	0.00	1.00	1.00	1.00	1.00
2	0.76	0.74	1.00	1.15	1.00
3	0.26	0.54	1.00	1.00	1.00
4	0.56	0.65	1.00	1.00	1.00
5	0.56	1.00	1.00	1.00	1.00
Average	0.43	0.79	1.00	1.03	1.00

cation of a break such as would be expected if a critical electron velocity is required for killing.

It is to be remembered that the treatment of data throughout has been purely qualitative and is to be taken as such. Only on this condition, for example, has it been considered justifiable to take averages of certain of the pollen readings.

It is evident that certain pollens possess properties which *a priori* recommend them for use as biologic media in radiation work. The pollen of the diploid lilies is susceptible to ready germination in artificial culture, requires but a few hours to attain a growth which will permit of a rapid statistical evaluation, is conveniently large, produces a tube which is non-branching and usually straight enough to be measured with fair accuracy, can be spread evenly, and can be readily cleared, if necessary, to view the nuclei. The disadvantages of the material are grave, however, and demand a refinement of technic without which pollen may well be disqualified for this work. Chief among these is the unusual capriciousness of germination, which has been emphasized by a number of workers,[17] and notably by Brink,[18] and with which we have had extensively to cope. Variations in concentration of available oxygen and hydrogen, in hydrogen ion concentration of the medium, in humidity and temperature, are all reflected in germination rates and percentages. In addition, there is a large deviation depending upon the proximity of the grains to one another, as Brink has shown for *Cucumis* and *Nicotiana* and as we have been able to confirm for some of the lilies. Finally, there is a surprising variability, even from anther to anther of the same flower, in the viability of different samples of pollen germinated under the same conditions, which cannot be accounted for. These difficulties, however, are very largely technical, and it should be possible to overcome them.

CONCLUSIONS

Qualitative evaluations of the survival ratio curves of inhibition to pollen tube and mycelial growth in pollen grains and mold spores have been made with soft x-rays, hard x-rays, and cathode rays. Energy measurements have been made of the three sources in the same units, and a comparison of the incident energy inputs required to produce roughly equivalent survival ratios in the same material has been made for the three sources. The incident energy required for hard x-rays has been found greater than that for soft x-rays by a factor of about 2.1 for mold and about 6 for pollen—a disparity which may not be significant. The disparity between cathode rays and soft and hard x-rays is not considered significant.

A comparison has likewise been made of the relative resistance of pollen grains and mold spores to the same form of energy. The reaction of the two types of organism was closely similar.

A study has been made of the suitability of the pollen of the diploid lilies as a

[17] Bucholz, J. T., and Blakeslee, A. F.: Am. Jour. Bot., July, 1927, **14**, 358–369.

Futt, N. L., and Ayyar, G. G.: Agric. Jour. India, May, 1928, **23**, 190–202.

[18] Brink, R. A.: Am. Jour. Bot., April, 1924, **11**, 218–228.

biologic medium for radiation work. It has been found to possess many desirable properties but certain undesirable features which, if not technically overcome, will invalidate it as reliable material.

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THE APPLICATION OF KYMOROENTGENOGRAPHY TO THE DIAGNOSIS OF CARDIAC DISEASE[1]

PART II

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IN the consideration of the application of roentgenkymography to the study of the abnormal heart it is important to understand at the outset that the kymographic wave is not a mystic symbol capable of expressing the particular disease of the heart. It expresses only the movement phenomena of the heart and indicates the deviation from the normal, only insofar as the particular lesion affects the movement.

Deviations of the kymographic waves from the normal may result either from:

(1) Disturbances of rhythm which produce variations in the character and periodicity of the movements.

(2) Intrinsic changes in the muscle itself, hypertrophy, atony, or degeneration.

(3) Extracardiac influences which modify the anatomic relationships of the heart and the intrathoracic pressure changes.

(4) Changes resulting from valvular defects which produce abnormal vibrations and variations in the chamber movements.

(*1*) *Changes resulting from disturbances in the character and periodicity of movement. Cardiac Irregularities.*[2]—By a study of successive cycles, the presence of disturbance in rhythm may be demonstrated by noting the variations in the amplitude and time relationships of the waves. Sinus arrhythmias, extrasystoles, auricular fibrillation and flutter, and heart block may thus be graphically demonstrated.

In auricular tachycardia the compression which the waves undergo is such as to blot out their individuality, so that there is produced a blurred, serrated outline. In ventricular or nodal paroxysmal tachycardia, the auricular waves maintain a normal contour, as the frequency is not increased.

Each frame over the ventricular contour contains two or more waves, depending on the rate. The wave is high and its contours steep. The diastolic limb shows a relative shortening, and approximates a straight line. There may be a slight blunting of the apex of the wave, due to a relative slowing up of the presystolic outward movement. The sound phenomena vibrations are not usually visualized.

Ventricular extrasystoles may be recognized by finding over the left ventricular contour, an interruption of the sequence of regular waves, by a wave of smaller amplitude, the extrasystole. This is followed by a wave of enlarged amplitude with a slow diastolic rise. The systolic limb of the extrasystole is relatively slow as compared to the normal wave preceding it while that of the compensatory wave, after the extrasystole is longer than normal. The extrasystolic wave appears earlier in the apical than in the basal portion of the heart and travels upward.

The corresponding change in the movement traced by the aorta depends upon the time relationship between the premature beat and the normal beat which preceded

[1] Read before the Fourth International Congress of Radiology, Zürich, July, 1934.

[2] Paroxysmal tachycardias and premature beats (or extrasystoles) are of three types: auricular, ventricular, and nodal, depending on the origin of the "ectopic" stimuli either in the auricles, ventricles, or auriculoventricular node. The determination of the type is important because of the varying prognostic significance of the different types and because they may be associated with otherwise unrecognized heart disease. For the study of cardiac irregularities, it is necessary to increase the number of cycles in each frame. This may be done by covering every other or every second and third slit and thus increasing the duration of movement of the recording surface. This has the deficiency of diminishing the number of movement points. It, therefore, becomes necessary to adjust the slits so that movements of special points of the cardiac contour are recorded, for instance, the left ventricular contour, the left auricular contour, the right auricular contour, and the vascular contour.

it. If the premature beat is one in which the contraction has taken place so early that the pressure is not sufficient to open the aortic valve, etc. (frustrated contraction), no corresponding wave is registered on the aortic shadow. On the other hand, the prolonged filling of the left ventricle, following the extrasystole and its sudden emptying after the compensatory pause, results in an aortic wave of increased amplitude. When the extra-ventricular waves are visualized in the upper part of the ventricle only, they are not associated with corresponding aortic waves.

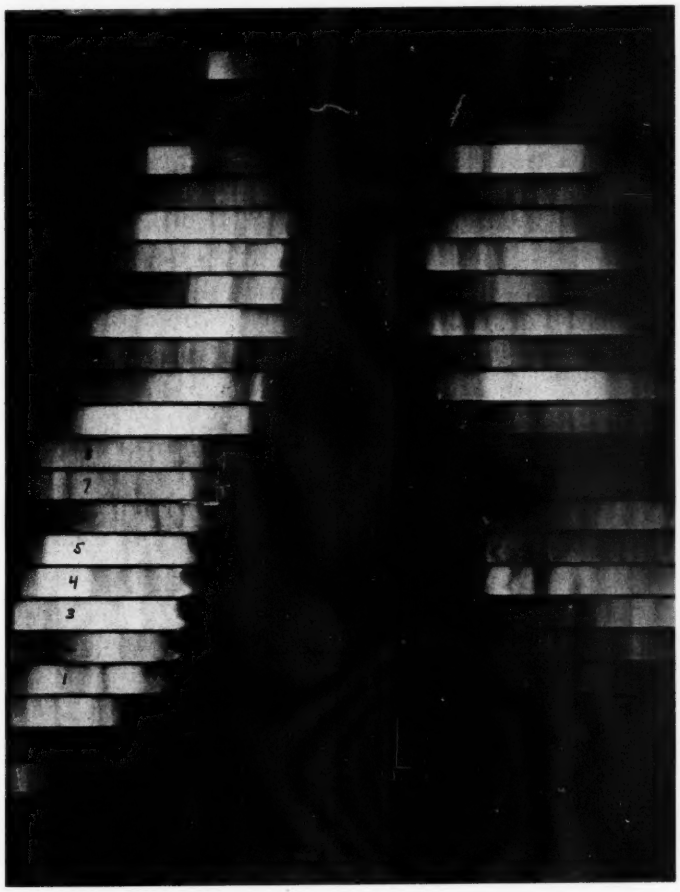

Fig. 1-*A*. Figs. 1-*A*, 1-*B*, and 1-*C*, are kymograms representing different types of heart action. Slow ventricular waves are to be noted over the left contour in frames from 1 to 8 but also over the lower right contour in frames from 1 to 7 indicating that the lower right contour in the living is always formed by the right ventricle—more so in vertical than in horizontal hearts.

Heart block is detected by a comparison of the frequency of auricular and ventricular contractions. Since the auricular waves do not now regularly bear the imprint of the ventricular wave, pure undeformed waves of auricular origin may be demonstrable. There may be considerable variation in the number of auricular systoles that occur during ventricular diastole in the same frame. The ventricular waves are irregular in sequence and amplitude, but generally show a marked increase in amplitude. This is due to the effect of a greater number of auricular

systoles in cycles when the larger ventricular excursion is noted and to the increased left auricular pressure. The apical portion of the wave is deformed by prominent serrations corresponding to the first heart sound. The location of the break on the diastolic limb varies in different waves. In total block the two limbs of the ventricular waves may be practically identical in form.

Fig. 1-*B*. The left ventricular contour in the lower nine frames bears prominent ventricular waves of practically equal altitude, indicating a uniform motion of all parts of this chamber. In the valleys of the ventricular waves in frames 8 and 9 are small peaks—left auricular motion. The auricular appendix (frames 10 and 11) shows motion of the ventricle and auricle, these frames showing two sharp peaks, auricular movement and two blunt waves, ventricular movement. Frame 12 shows the pulmonary artery waves and lateral to it waves indicating the movement of two parallel vessels which extend toward the apex. Frames 13 to 16 bear aortic waves; in 17 to 21 the waves are those due to motion of the left subclavian artery. Ventricular waves are seen over the lower right contour to frame 7. Frames 7 to 9 bear right auricular and ventricular, while 10 to 14 show a continuation of high sharp aortic waves in the valley between which is a blunt peak, auricular in origin, motion transmitted into the vena cava.

In auricular fibrillation the regular sequence of distinct and definite waves is replaced by irregular, ill-defined serrations, or there may be a complete absence of

peaks over the entire right contour from diaphragm to the aortic shadow. On the ventricle the diastolic limb of the wave is prolonged and the systolic relatively shortened. The peaks are of unequal amplitude.

(2) *Intrinsic changes in the musculature, hypertrophy, atony, or degeneration.*

The kymographic waves are modified, depending on the extent of the muscular change.

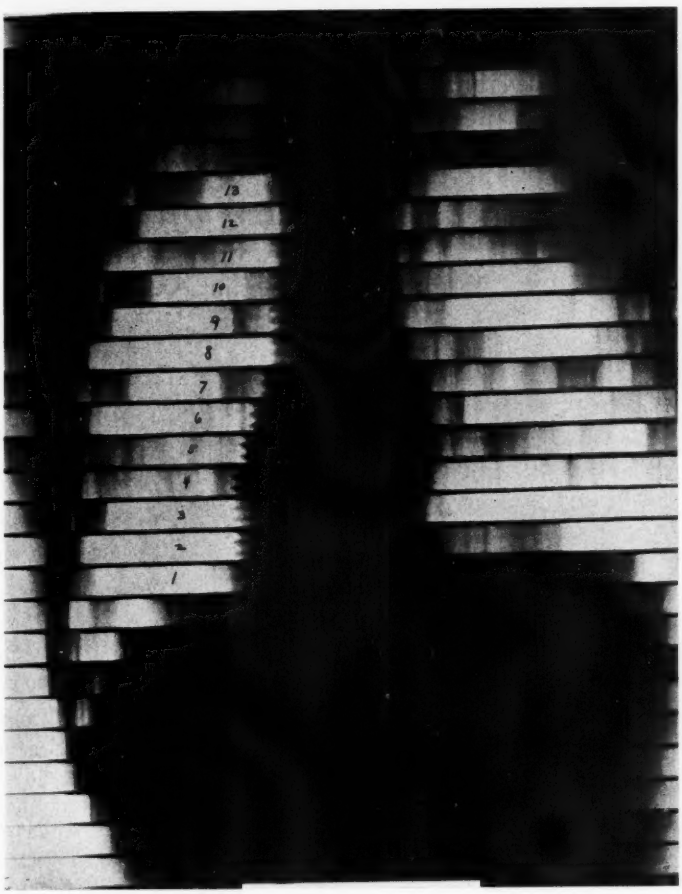

Fig. 1-*C*. Rapid heart action. Note the increase in number of the waves in each band. The striking changes in the physical density of the heart during the cycle of movement are shown by the alternating black and white zones in every band.

In 7 and 8 on the left side, the peaks are blunted because they are now composite waves indicative of ventricular and auricular motion. Pure left auricular waves may be seen in frame 8 in the right contour. On the right side in 6 and 7 the frames bear a combined auricular and ventricular wave. In this habitus, therefore, a small portion of the left auricle forms the upper right cardiac contour. In *A* the ventricular waves are rounded (sine form), the legs being curvilinear. In *B* the ventricular waves are trapezoid or pointed, the legs being rectilinear. In *C* the ventricular waves are sharply peaked and steepled. The amplitude of the contraction over different portions of the left ventricle is practically the same. In *A* the heart action is slow. In *B* the heart action has a medium rate. In *C* the heart action is fast.

Whenever excessive volumes of blood

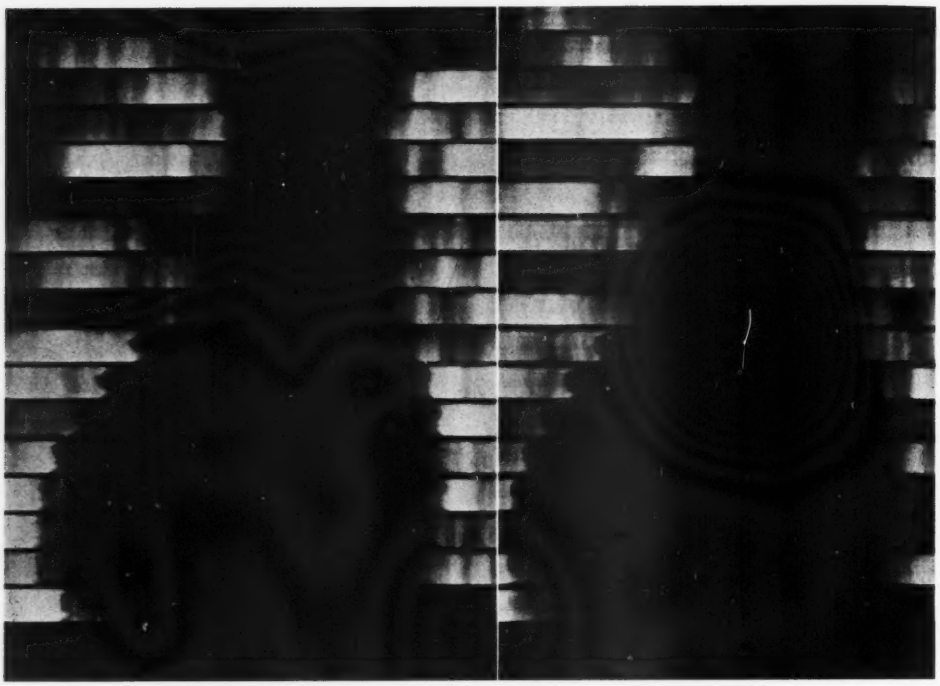

Fig. 2-*A*. Fig. 2-*B*.

Fig. 2-*A*. Kymogram of normal young adult taken in inspiration.
Fig. 2-*B*. Kymogram of same subject taken 10 seconds after the Valsalva procedure (deep inspiration, followed by forced expiratory effort with mouth and nostrils closed). There is to be noted first, that the heart has grown generally smaller. It is also more rounded, due to a protrusion in the left auricular region, and the waves over the left ventricle have lost their peaks and have become blunted and rounded, the second phase of diastole being practically a plateau. The heart has slowed down somewhat. The aortic contractions are of increased amplitude and the pulmonary artery waves are of diminished amplitude. Thus the heart empties itself more freely than it fills. Actually, both margins, particularly the right, move inward with each cycle during the test. This reaction cannot be induced in hearts showing hypertrophy.

are returned to a chamber of the heart, or when the ejection is below normal, dilatation follows. The ventricles resist this stretching by virtue of a muscular tone inherent in the living normal cardiac muscle. When the normal resistance to stretching is diminished or lost through a reduction or loss of muscular tone, the diastolic distention becomes pathologic.

In beginning dilatation, the ventricular waves have considerable height, even in repose and respond to the slightest exertion by a further increase in altitude. The diastolic period seems shortened and the systolic period somewhat lengthened.

Under pathologic conditions of diminished tone, the systolic discharge is apparently kept normal or is actually somewhat increased by a compensatory mechanism—increased initial pressure. This is shown by the presence of ventricular waves, the diastolic limb of which is rounded (convex) and the systolic concave. The waves are devoid of sound phenomena. When the compensatory mechanism fails, the systolic discharge is apparently less than normal in spite of a much greater distention. This is shown by diminished ventricular movement. There may, in fact, be a complete abeyance of the movement of the apical portion of the heart, this contour bearing no waves and showing straight edges. Should the condition of the heart muscle improve under therapeutic measures, the waves may again be found over the contour.

In concentric hypertrophy of moderate degree, without dilatation, there is no change in the morphology of the wave. When, however, the dilatation is associated with hypertrophy well-defined waves are present only over the upper part of the ventricular shadow, the apical portion showing diminished movement. In cardiac failure the amplitude of the waves diminishes until it becomes barely perceptible and with this there are marked morphological and dimensional changes. When the waves of exaggerated amplitude change to waves of lessened amplitude, with a continued increase in the size of the heart, it is a sign of serious prognostic import. Small ventricular waves do not, however, always indicate myocardial insufficiency. Extremely small ventricular waves are present in certain cases of mitral stenosis when the left ventricle is small—the cardiac contour and size must be taken into consideration. Reduced apical movement is also commonly found in senile hearts, but is also found normally.

The left ventricular motion has been divided into two types by Stumpf. In Type I the amplitude of the kymographic wave is greatest at the apex, and in Type II the maximum amplitude of the kymographic wave is at the base. Stumpf states that a great majority of normal hearts show Type I movement and that although Type II is occasionally observed in normal hearts, it is seen regularly in pathologic hearts. This change in movement is interpreted in terms of structural changes, on the basis that hypertropy or atrophy occurs in zones and only seldom affect the whole muscular apparatus uniformly. The outlet passage always hypertrophies first and to the greatest extent in the left ventricle, which brings about a change of the volume of the movement in corresponding zones, *i.e.*, increase in movement cranially (Type II).

The above conclusion for normal hearts are not confirmed in a series of 121 examination of young adults. While it is true that many hearts show a predominant motion at the apex (Type I) and others a

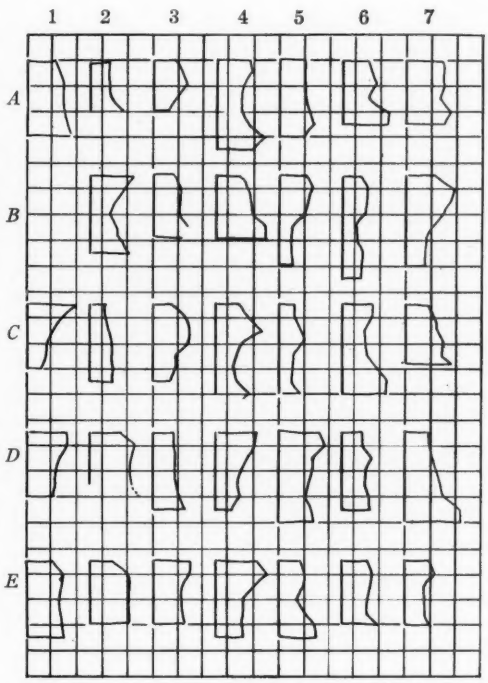

Diagram I. Analysis of 34 kymograms showing the point of maximum movement of the left ventricular contour. Maximum amplitude at the apex is illustrated in *C*-6, *D*-7, *E*-5, and toward the base in *B*-7, *C*-1 and *E*-4. *A*-3 shows the greatest amplitude of motion in the middle portion of the ventricular contour, while in *B*-2 and *A*-4 the amplitude is large at the apex and base and smallest in the middle region.

maximum movement toward the base (Type II), there is a large group which shows no gross preponderance at any one region. A few show maximum movement in the middle zone of the left ventricular shadow, although the amplitude of motion as a rule is least in the middle zone. Not infrequently there are found kymograms with large amplitude of motion both at apex and base with small movement in the middle. Type II movement is regularly found in normal hearts and by no means limited to pathologic hearts.

In a series of 121 cases, 80 showed a predominant movement varying from slight to marked, either at apex or base. Of these 80, 44 had movement greatest at the base (Type II), and in 36 the movement was greatest at the apex (Type I). The remaining 41 cases showed no preponderance

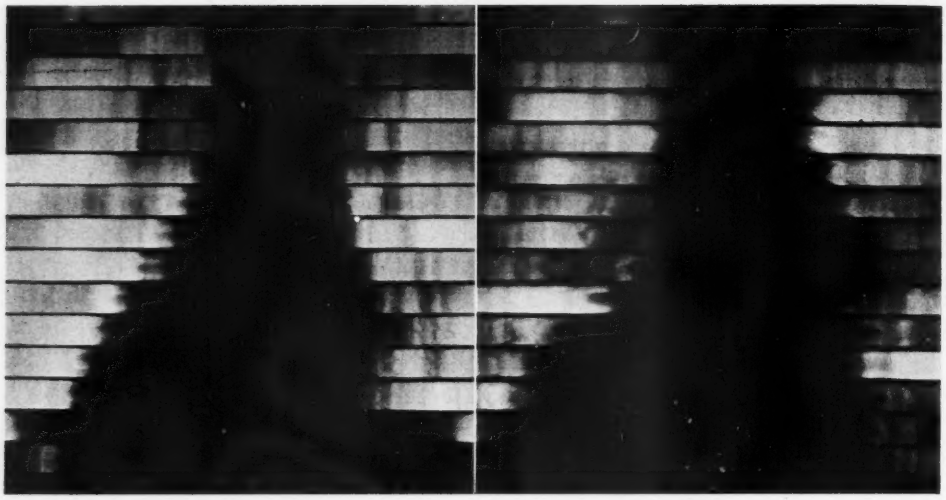

Fig. 3-*A*. Fig. 3-*B*.

Fig. 3-*A*. Kymogram of a normal young adult taken in moderate inspiration.

Fig. 3-*B*. Kymogram of the same subject taken 10 seconds after the Müller procedure (deep expiration followed by forced inspiratory effort with nose and mouth closed). There is to be noted in this figure that the heart has grown generally larger. It is the right heart which is primarily involved in this enlargement because the emptying of the right ventricle is retarded. The waves of the right ventricle have greater amplitude than those of the left. Prominent waves are noted over the vena cava shadow. The pulmonary artery pulsations are more prominent than the aortic. This is the counterpart of the picture of obstruction at the pulmonary valves or beyond it.

at any point, large amplitude at apex and base with smaller amplitude between, and in a few cases maximum amplitude in the middle region (Diag. I).

To sum up the findings, it may be said that degenerative myocardial changes of sufficient severity to produce electrocardiographic changes are always associated with kymographic changes.

Degenerative changes in the aortic wall result in sclerosis, calcifications, and aneurysmal dilatations. Sclerotic changes of the aorta are ordinarily shown by a widening, elongation and tortuosity and a sharply projecting aortic arcus. The aortic waves usually show no deviation from the normal in simple sclerosis. The associated ventricular hypertrophy may, however, produce waves of increased amplitude. In the presence of calcification, the peaks become flatter and the amplitudes smaller. In annular calcifications of the entire aortic wall, this phenomenon is very pronounced. The lateral motion is of small amplitude, the point of maximum dilatation is attained late, and the peak loses its characteristic sharpness. Nevertheless, distinct motion can be seen even in very marked calcifications.

In hypertension, the amplitude of the aortic waves is small, and the apex is blunted in spite of the large ventricular waves.

The amount and extent of movement in aneurysmal dilatations is variable, and depends on the extent of the clot formation in the wall of the sac. The characteristics of the aortic wave are not changed over the aneurysmal area, though a slight delay in point of time may be found on comparing the peak of the outward thrust to that of a wave over a normal portion of the aorta.

Aneurysms of the ascending aorta usually show very pronounced excursions. The form of the wave deviates from the normal. The inward and outward moving limbs resemble each other. In point of time, the peak of the wave is attained late—at the end of ventricular systole. The end of the medial motion is attained

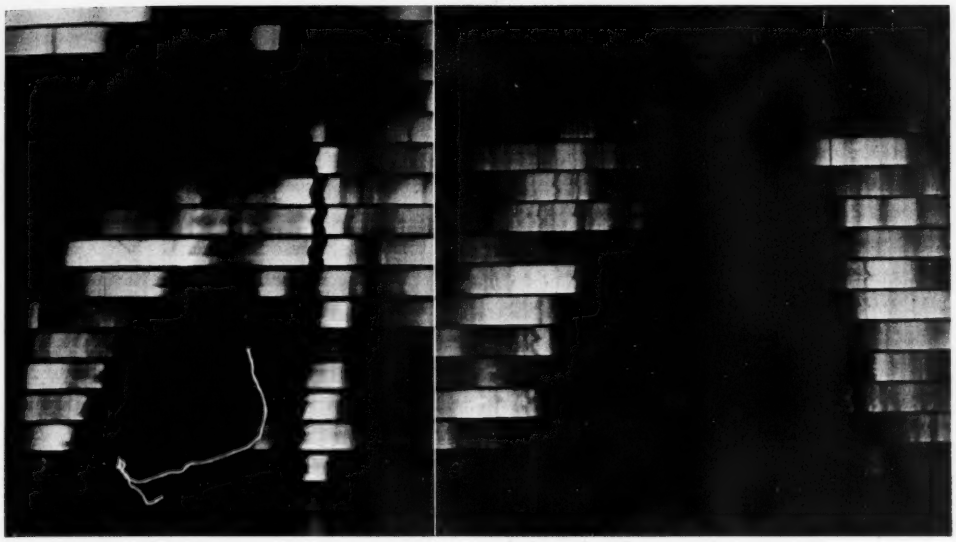

Fig. 4. Kymographic examination of the esophagus after the administration of a contrast bolus. A kymographic examination of the esophagus gives considerable information regarding the movement of the cardiovascular structures in relationship to it. In the ordinary fluoroscopic examination, only the lower portion of the esophagus shows definite movement. The kymographic examination, however, shows that every portion of the thoracic gullet shows definite movement imparted to it by the particular cardiovascular structure in relationship to it. In the lower portion, two waves are shown indenting the gullet shadow in each band, one due to auricular diastole and one to ventricular diastole. Above, the aorta imposes its movement in varying intensity upon different portions of the esophagus. Considerable information regarding the auricular movements may be obtained by this method because of the large extent of auricle in relationship to the gullet.

Fig. 5. Hypertension. There is exaggerated movement of the left ventricle as shown by waves of considerable amplitude. The aortic waves are relatively low, a characteristic of hypertension. Even in this individual of the supersthenic habitus, pure left ventricular waves are seen in the lowest bands on the right side.

simultaneously by all portions of the vessel.

Aneurysms of the descending aorta show as protrusions to the left, but may also show to the right. Aneurysmal sacs extending toward the right usually bear no waves.

The peculiar character of the wave over the aneurysmal sac, the wave with symmetrical limbs, permits the differential diagnosis of this lesion from mediastinal tumors either motionless or moved by transmitted pulsations.

The presence of small and thin areas of calcification, frequently not detectable on the ordinary roentgenogram, are clearly shown in the kymographic waves.

Aneurysms of the Heart.—Partial aneurysms of the heart may be overlooked by fluoroscopy, not only when located in the apex or in the antero-inferior wall of the right ventricle, but even when located in the lateral aspect of the ventricle. When the pocket produces an actual localized projection of the left contour, the lesion may sometimes be isolated by the usual roentgenological methods. Partial aneurysms may, however, be shown kymographically by waves of diminished amplitude over a localized area of ventricular contour with normal waves above and below the area. This is also the finding when the sac is small. When an actual sac is present there is a definite reversal of the waves over a localized area. With each systole the inward moving limb is replaced by an outward diastolic movement because the walls of the sac, having lost their contractibility, the sac becomes distended by the systolic pressure in the ventricle. In other words, there is present in the ventricular contour a wave having the time and form characteristics of the aortic wave.

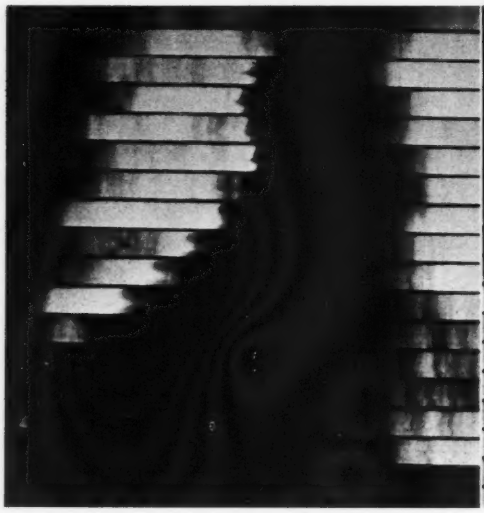

Fig. 6. Kymogram of a case of aortic stenosis with marked left ventricular enlargement. Aortic waves of increased amplitude are seen over the entire aortic contour. Normal ventricular waves are present over the lower right contour (right ventricle). Over the lower part of the left ventricular contour, are waves which have the general characteristics of aortic waves. The peaks correspond almost exactly to the maximum ventricular systole. In other words, this portion of the heart contour moves outward when the remaining portions of the ventricle move inward. This would indicate an area of myocardial degeneration and a ventricular aneurysm.

Fig. 7. Kymogram and EKG of a case of syphilitic stenosis beyond the pulmonary valves with complete heart block. Note the exaggerated amplitude of the ventricular waves present on both sides of the cardiac contour—the right auricular waves of high amplitude are interposed between the ventricular waves. The pulmonary artery waves are more prominent than the aortic. A correlation with the EKG shows a variation in the shape of the diastolic limb of the ventricular wave due to a variation in the point of the break of the wave. This is due to the variation in the time of the auricular systole (P wave). The T wave does not end with the end of systole in every cycle. It seems to shift about.

(3) *Extracardiac influences which modify the anatomic relationships of the heart and the intrathoracic pressure changes.*

The lungs appear to exert a dampening or cushion effect on the heart movements. Thus in pneumothorax, the waves over the particular portion of the heart in relationship to the air-containing cavity show a markedly increased amplitude, while pleural effusion and consolidation have the opposite effect on contiguous portions of the heart.

By giving a graphic record of the movement of structures, the kymogram is of value in the differential diagnosis of pericardial from cardiac lesions.

In pericardial effusion, the waves are markedly diminished in amplitude and ill-defined over the basal portions of the deformed median shadow, yet show good form and amplitude over the apical portion. In cardiac hypertrophy the waves may be diminished over apical portions of the heart, but the upper part of the ventricular contour shows characteristic waves. However, in large effusions there is a lack of clearly defined waves over the entire median shadow. Density changes, corresponding to systolic and diastolic volume of the heart may, however, be made out, and the heart contour may be recognized in the sac.

The distortion of the lower left cardiac contour and the left apex by a mediastinal pleural exudate extending to the left can be differentiated from heart form of pericardial effusion by the finding of kymographic waves of unchanged amplitude and form, over the area.

Calcification of the pericardium does not modify the size or character of the waves to any appreciable extent. Pleuro-peri-

cardial adhesions, however, diminish the amplitude of the waves over the involved area.

The kymogram is of value for the determination of the significance of distortions of the upper median shadow. Fluoroscopy does not always permit of the differentiation of the vascular pulsations from the transmitted movements, and the kymographic study is helpful under such circumstances. Tumors, substernal thyroids or cysts, etc., usually show no movement waves. A deformity of the median shadow due to aortic dilatation would show definite aortic waves associated with density changes. The transmitted pulsations show as waves without density changes.

Tumors of the mediastinum are generally motionless. Encysted effusions may show transmitted pulsations.

Besides this, the entire extent of the pulsating structure may be studied in the conglomerate shadow of the mediastinum, and the continuity of shadows, otherwise demonstrable with difficulty, may be determined. Thus the entire extent of the aorta may be determined with ease in the kymogram.

(4) *Modification of the kymographic waves resulting from changes due to valvular defects.*

Among the results of valvular disease are: (1) A variation from the normal state of filling of the chambers related to the valve involved; (2) Secondary and compensatory changes in the muscle walls.

The valvular lesions are manifested by: (1) Changes in the distribution of the waves; (2) Changes of the character of the waves and their dimensional relationships; (3) Changes in time relationships of the various phenomena of the cycle; (4) Changes in the vibrations associated with the sound phenomena.

It is important to attempt to distinguish between the effects of the disturbed valvular action and effects of the abnormal anatomic and physiologic activity of the myocardium—not a simple task at this stage of the art of kymographic diagnosis.

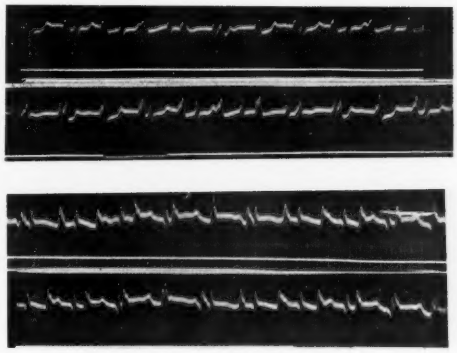

Fig. 7

A clue to the changes produced by variations from the normal state of filling of the chambers may be found by making kymographic examinations during such procedures as the Müller and the Valsalva tests, which, by producing changes in intrathoracic pressure, artificially reproduce some of the changes found in organic lesions.

A kymogram made during the Müller test illustrates how the heart chambers accommodate themselves to a temporary ventricular overfilling. This test produces an effect similar to that which exists when there is an obstruction to the flow of blood from the right ventricle, as, for instance, in stenosis of the pulmonary artery, or an obstruction in the pulmonary circulation. The kymographic exposure is made a few seconds after a maximum expiration, followed by an inspiratory effort with nostrils and mouth closed. It shows graphically, a rapid enlargement of the heart with each cyle and growing prominence of the right contour waves over the left, both auricular and ventricular. The waves on the vena cava shadow are of increased amplitude, while the aortic waves show diminished amplitude. (Fig. 3.)

A kymogram made during the Valsalva test illustrates how the heart chambers accommodate themselves to a decreased inflow. By this procedure the heart is gradually emptied of blood. The kymographic exposure is made a few seconds after a maximum inspiration, followed by

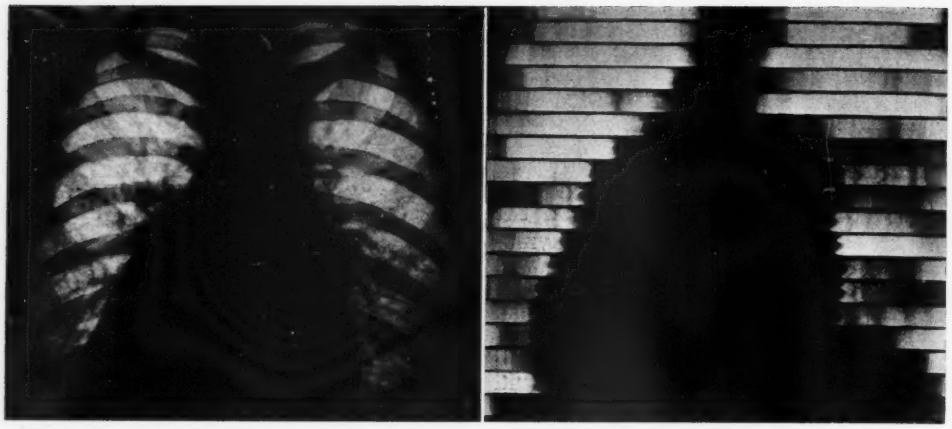

Fig. 8-*A*. Fig. 8-*B*.

Fig. 8. Kymogram of a case of mitral stenosis and insufficiency: *A* Regular examination; *B* Kymographic examination. The characteristic contour may be made out. Note the inconspicuous aortic waves, the prominent pulmonic and auricular waves. The ventricular waves are also prominent over almost the entire right contour. The first phase of diastole is shown as a straight line without the usual break. Then follows a plateau indicating the absence of movement of the left ventricle, to be followed by a rapid systole. On the right side the waves over the lower portion also show this characteristic, while over the upper portion of the right contour, the waves are rounded. The sound waves do not show.

a forced expiration with mouth and nostrils closed. The emptying of the heart exceeds the filling with each cycle and the kymogram shows graphically how the heart grows smaller in size with each contraction. All parts of the heart are simultaneously affected. The margins continue to move in until the heart attains its minimum dimension. The ventricular and auricular waves show a gradually diminishing amplitude with increase in the intrapulmonary pressure. (Fig. 3.)

The changes in the size and shape of the chambers, which give the cardiac silhouette its characteristic shape in various valvular lesions, naturally modify the normal distribution of the kymographic waves.

The accentuation of the right contour as found in organic lesions of the heart may be due to either enlargement of the right auricle or of the left auricle. If due to the right auricle, the whole profile may bear auricular waves which may show peaks surmounting in altitude those imposed on the auricular contour by the ventricle.

In consideration of the changes produced by left auricular enlargement it is important to understand that the cavity of the left auricle, sometimes normally, but always under pathologic conditions, may not only extend to the left, in back of the pulmonary artery, but may also extend to the right, sometimes only to the right, behind and above the right auricle. The right contour now consists in its upper third of the left auricle, which overlaps the aortic shadow above and the right auricular shadow below. But under such conditions, the kymographic waves of the upper part are not auricular in time or character, for the contour passively follows the movement of the ventricle, being thrust out with the ventricular systole. The intrinsic left auricular movements are too feeble to be recorded. This is frequently observed in mitral valvular disease.

The lower right contour is not deviated by changes in the right ventricle. When the right ventricle enlarges, it does so not to the right, but to the left, and downward. Thus in pure right ventricular enlargement, such as follows congenital pulmonary stenosis or syphilitic stenosis of the artery beyond the valves or in a patent ductus, the right cardiac contour may show

ventricular waves as under normal conditions in its lowermost portion.

When, on the contrary, there is marked enlargement of the left ventricle, the intraventricular septum is displaced to the right and the right ventricle may form a larger part of the right contour. However, an increased number of ventricular waves over the right contour by no means indicates by itself that this is due to left ventricular enlargement. The typical findings of shape and size of the heart shadow must be present. With an increased obliquity of the heart's axis, as in the subthenic habitus or with low position of the diaphragm, an increased extent of ventricular waves to the right may be observed normally.

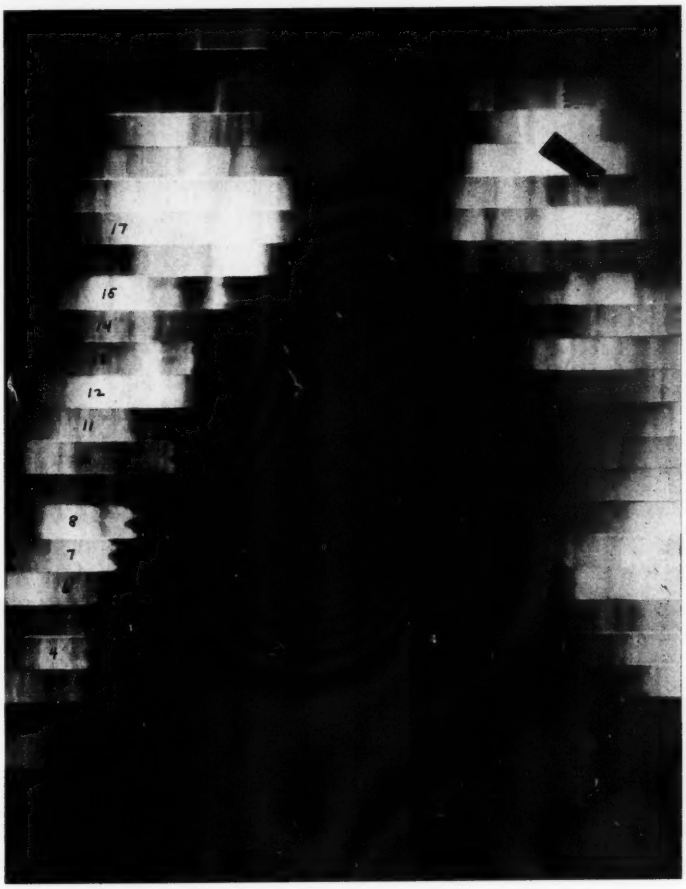

Fig. 9. Double mitral lesion. Dyspnea, cyanosis, edema, large liver. Loud systolic murmur over the whole cardiac region, propagated to the axilla and back. Presystolic rumbling at the apex. EKG shows complete arhythmia with auricular fibrillation. The kymograph shows the typical contour of double mitral valvular disease, with marked dilatation of the left auricle. The right contour bears flat ventricular waves, synchronous with those on the left contour. There is also marked pulsation of the pulmonary arteries. There is marked dilation of the pulmonary artery, particularly on the right side where low rounded waves may be seen. On the left side, the pulmonary artery has been pushed up by the markedly dilated left auricle.

It is conceivable, also, that an aneurysm of the intraventricular septum may push the right ventricle outward to such a de-

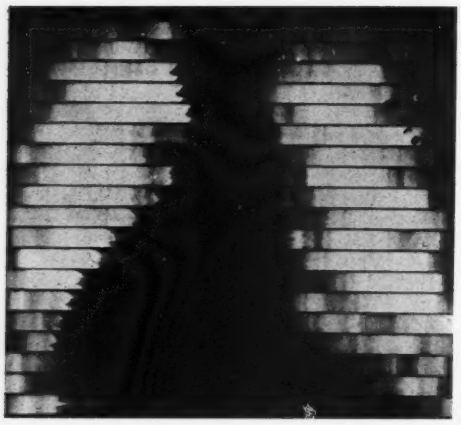

Fig. 10. Kymogram of the heart of aortic insufficiency. The maximum dilatation of the ascending arch is practically synchronous with the closure of the mitral, but the peak on the descending arch is attained relatively late. The failure of the aortic valves to close produces the dilatation of the ascending arch immediately; the delay in the full dilatation of the descending arch is compensatory for the establishment of the necessary ventricular aortic pressure. On the ascending arch the aortic wave rises rapidly, falls back slowly at first, and then drops suddenly and sharply. On the descending arch the wave rises rapidly, falls back sharply and then retracts slowly. The left auricular waves are exceedingly prominent. The vibration associated with the second sound shows in an exaggerated form over the ventricles, but the first sound vibration cannot be made out. EKG shows P notched, QRS slurred, T inverted, sinus tachycardia.

gree as to produce well-marked ventricular waves over the entire right contour.

MITRAL DISEASE

In insufficiency, at the instant diastole begins, there is a rapid and extensive dilatation of the ventricle due to a large volume of blood entering it, shown by the shape of the first portion of the diastolic limb of the left ventricular wave. There then follows a slow, relatively long terminal portion of diastole, as if the ventricle then remained practically motionless after the first flood-like filling, until systole begins. This terminal diastolic movement may even show an inward or mesial sloping instead of an outward movement as normal, the inversion being more marked as the base of the heart border is approached. The systolic limb is normal in character.

In mitral stenosis, on the other hand, the diastolic limb shows as a uniform line without break due to slow filling of the ventricle.

In mitral stenosis there is marked deformity at the apex of ventricular wave due to phenomena associated with the production of the first sound. In fact, when such deformity is marked, and the rhythm is regular, the diagnosis of a tight stenosis is corroborated, if the characteristic heart shape is present. The systolic limb is relatively rapid and the systolic discharge is reduced as shown by the low amplitude of the aortic waves.

During ventricular systole there is normally an increase in the volume of the auricle. In mitral insufficiency this increase during ventricular systole is very marked. The extent depends on the degree of insufficiency, the tonicity of the muscle, and extent of the dilatation of the chamber. In minor degrees of insufficiency, with but slight dilatation, the hypertrophy of the auricular walls is a compensatory element which may counteract this influence. But usually this compensatory mechanism is not operative. With beginning ventricular diastole, the auricular volume diminishes rapidly.

The left auricle appears to bear the brunt of the back pressure effects. Since insufficiency of the valve causes the mean left auricular pressure to rise during ventricular systole (when it should fall), a movement, ventricular in time, of increased amplitude, is present over the contour at the beginning of systole, not only in the usual area but also over the upper half or more of the right contour. In some cases almost the entire right contour may now show this movement. However, in some cases true auricular systolic phenomena may also be observed in addition.

When the left auricle is excessively dilated, its walls have the character of a thin aneurysmal sac, over-distended by the blood flowing back from the left ventricle.

It then follows passively the exaggerated movement of the ventricle. This explains the waves resembling aortic waves there is a very prominent notch imposed on the retracting limb in the pulmonic wave which corresponds in time to the

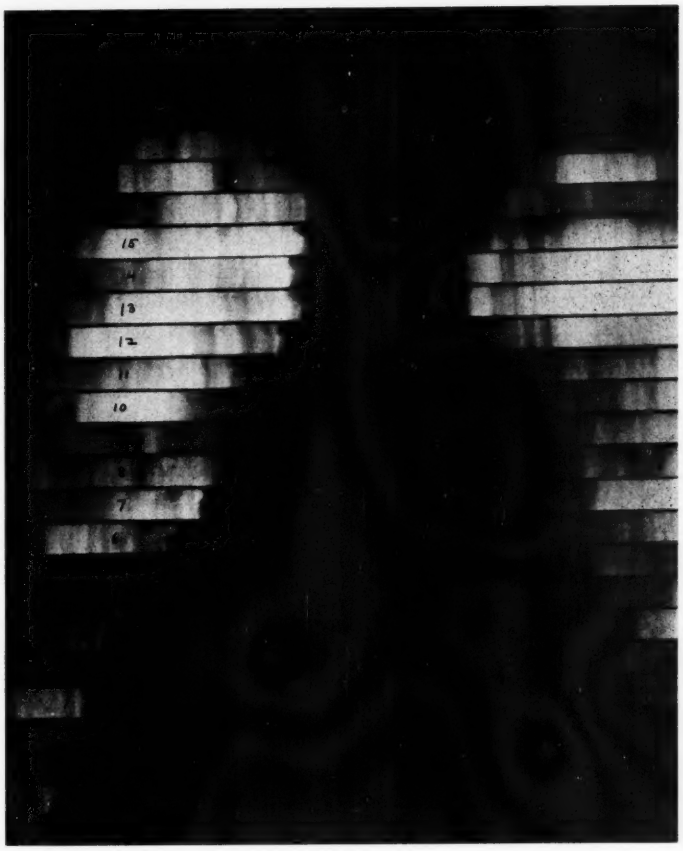

Fig. 11. Kymogram of a case of combined valvular disease. The aortic waves are not seen over the descending arch shadow. The amplitude of the waves is small. The ascending limb (outward thrust) rises slowly. The pulmonary artery is dilated. The right auricular contour bears auricular waves of considerable amplitude. There is practically no movement over the apical portion of the heart. Towards the base the ventricular waves show a slow primary diastolic phase, which is followed by a period during which the ventricle either makes no further outward movement, or makes an inward movement (the rounded peak of the wave). This is then followed by a short sharp systole. The maximum dilatation of the descending arch is not attained until left ventricular systole is fully ended. The pulmonary artery reaches maximum dilatation in advance of the maximum aortic dilatation.

over the upper part of the right cardiac contour. When the regurgitation is marked, the first sound notch disappears, particularly when decompensation is present.

The pulmonary artery waves are of greater amplitude than the aortic, and second sound. There is also a strong pulsation of the lung vessels extending to the periphery, which becomes very marked in decompensation.

The striking features of the kymographic examination in mitral valvular disease are: (*a*) changes in the character of the

diastolic limb of the ventricular waves (rapid filling in insufficiency, slow filling in stenosis); (*b*) changes in the character and distribution of the waves of the left auricle; (*c*) changes in the character and distribution of the pulmonary artery waves.

AORTIC DISEASE

When the aortic orifice is moderately narrowed the increased systolic activity maintains a normal systolic discharge and the aortic waves are not changed. The only abnormality consists in evidence of increased activity as shown by left ventricular waves of great amplitude and very frequently also accompanied by high right ventricular waves.

If stenosis is very great, there is less efficient emptying of the left ventricle in spite of the fact that intraventricular pressure during the systole rises to a great height and in spite of the lengthening of the period of systole. This reduces systolic discharge and lowers the amplitude of the aortic waves. In contrast, the pulmonary artery waves are prominent. The sound wave is imperceptible.

Over the left auricular area are prominent mixed auricular-ventricular waves. If myocardial weakness does not supervene, the blood is accommodated in the left auricle and its venous tributaries.

When muscular changes finally supervene, the left ventricle is dilated by a large volume of retained blood and a relative mitral change may occur.

In aortic regurgitation the ascending aorta begins to dilate, as shown by the out-thrust of the aortic waves, practically simultaneously with the onset of ventricular systole. This premature dilatation is practically simultaneous with the closure of the mitral valve and the first sound and is due to a wave transmitted through the incompetent similunar valve. There follows then a sudden retraction of the vessel wall. This primary peak is more prominent nearer the heart and diminishes as distance from the semilunar valves increases and is not at all registered in the descending arch. There then follows a slower second rise (peak 2) on the ascending arch synchronous with a similar rise in the descending arch. This is the true aortic wave. On the descending arch the apex of this peak is sometimes split. Then follows a very prominent incisura corresponding to the second sound and a third peak with a very rapid retraction. In the upper bands over the descending arch, a fourth peak is evident. On the descending arch following the sound indentation and the second peak there is a very rapid retraction of the vessel.

The amplitude of the aortic waves is markedly increased.

The first period of ventricular filling takes place very rapidly, as shown by the steep high first portion of the diastolic limb. The second phase is slower and longer. The end of the diastolic period is marked by a sharp peak (steeple) due to the increment contributed by the auricular systole. The systolic movement is delayed but of increased amplitude. It may, in fact, be stated that in aortic disease the greatest part of the diastolic filling takes place toward the end of diastole.

The valleys of the ventricular waves over the apex of the heart are clear, but near the base there is interposed a peak which corresponds to the beginning final retraction of the aorta (peak 3) and the period of collapse of the pulse. It represents the effect of the regurgitant wave and is apparently manifested predominatingly at the base and scarcely at all in the apical portion of the heart. The first sound serration is of diminished amplitude. The left auricular waves are prominent at the base of the shadow of the ascending arch.

The striking features of the kymographic examination in aortic valvular disease are: (*a*) disturbed time relationships between the aortic and ventricular kymograms; (*b*) qualitative changes in the contour of the aortic waves resulting from the regurgitation and the compensatory vascular phenomena; (*c*) qualitative changes in the ventricular waves resulting from the

changed hydrostatic conditions in the ventricles.

It is not yet possible to define exactly the value of the contribution of this newer method of roentgen examination, to the anatomic, physiologic, and clinical study of the heart, nor all its possible applications. The data already obtained would, however, indicate that its field of usefulness will be wide and that it will assist greatly in the solution of many difficult problems in the field of cardiodynamics. Thus the action of drugs on the heart muscle may be studied by roentgenkymography, utilizing as criteria the difference in the frequency and amplitude of the wave, and the changes in the movement of the pulmonic vessels, before and after the administration of the drug. So also, attempts have been made to determine the heart volume by comparing the systolic and diastolic areas as shown by the kymographic waves and utilizing the formula of Bardeen.

SUMMARY

The kymographic method contributes the following information to the morphologic and physiologic study of the heart:

1. The actual make-up of the cardiac shadow.
2. The shape of the heart as a whole, or any of its chambers during the various phases of movement.
3. Size of the heart in systole and diastole or any intermediate phase.
4. Characteristics of the movement of the heart as a whole or its various chambers.
5. Activity and accomplishment of the cardiac muscle.
6. The relationship of contraction to conduction phenomena.
7. The relationship of movement to sound phenomena.
8. A graphic representation of rhythm disturbances.
9. The extent and severity of myocardial changes.
10. The modification of the character distribution and time relationships of the chamber movements in valvular disease.

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SOME MATHEMATICAL ASPECTS OF RADIATION DOSAGE

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IT is found that tissue exhibits a property of "recovery from radiation effects." The rate of recovery is generally assumed to be exponential (1 and 2). Due to this property of recovery, the effective radiation dose (sometimes called cumulative) tends toward an equilibrium value, that is, a value at which the rate of recovery of the tissue equals the rate of dosage.

Assuming the fact of tissue recovery we will derive an expression for the effective (or cumulative) dose at the time just after it has been administered on the nth day. Since recovery begins the moment energy is absorbed by the tissue, we shall, for a first approximation, assume that the dose is administered instantaneously. To cover cases in which different doses are given on alternate days we shall take the case wherein D_i, the initial dose, alternates with a dose D_a on subsequent days. Let β be the recovery factor of the tissue for unit time. Thus β may be 4 per cent per day (3) as in the case of radium radiation filtered through 1 mm. of platinum, or it may be 8 per cent per day (2) as in the case of roentgen radiation of $\lambda_{eff} = 0.16$ Å. Let $k = (1 - \beta)$, or the amount of radiation effect remaining after one day.

First there is the case when n is odd. The contribution of the first day, A_1, to the effective dose will be $D_i k^{n-1}$; the contribution of the second day, B_2, will be $D_a k^{n-2}$, etc. Thus:

$$\begin{aligned}
A_1 &= D_i k^{n-1} \\
B_2 &= D_a k^{n-2} \\
A_3 &= D_i k^{n-3} \\
B_4 &= D_a k^{n-4} \\
&\cdot \quad\quad \cdot \\
&\cdot \quad\quad \cdot \\
&\cdot \quad\quad \cdot \\
B_{n-3} &= D_a k^{n-(n-3)} \\
A_{n-2} &= D_i k^{n-(n-2)} \\
B_{n-1} &= D_a k^{n-(n-1)} \\
A_n &= D_i k^{n-n}
\end{aligned}$$

The effective dose after n days is equal to the sum of the A's and B's. But:

$$\begin{aligned}
{}_i\Sigma A_j &= D_i(k^{n-1} + k^{n-3} + k^{n-5} + \ldots + k^{n-(n-2)} + 1) \quad (1) \\
{}_j\Sigma B_j &= D_a(k^{n-2} + k^{n-4} + k^{n-6} + \ldots + k^{n-(n-3)} + k) \\
&= D_a k(k^{n-1} + k^{n-3} + k^{n-5} + \ldots + k^{n-(n-2)} + 1) \quad (1.1)
\end{aligned}$$

The series in the right-hand sides of Equations (1) and (1.1) are geometrical progressions of which the first term a is equal to 1; the common factor $d = k^2$, and the number of terms are $z = (n + 1)/2$. The sum of such a progression is $S = \dfrac{a - ad^z}{1 - d}$.

Hence for the above series:

$${}_i\Sigma A_j = D_i\left\{\frac{1 - k^{2(n+1)/2}}{1 - k^2}\right\} \quad {}_j\Sigma B_j = D_a k\left\{\frac{1 - k^{2(n-1)/2}}{1 - k^2}\right\}$$

The effective dose, D_e, is then

$$D_e = D_i\left\{\frac{1 - k^{n+1}}{1 - k^2}\right\} + kD_a\left\{\frac{1 - k^{n-1}}{1 - k^2}\right\} \quad (n \text{ odd}) \quad (2)$$

When n is even, the contribution of the first day, A_1, is $D_i k^{n-1}$; that of the second day, B_2, is $D_a k^{n-2}$, etc., whereas:

$$\begin{aligned}
A_{n-3} &= D_i k^{n-(n-3)} \\
B_{n-2} &= D_a k^{n-(n-2)} \\
A_{n-1} &= D_i k^{n-(n-1)} \\
B_n &= D_a k^{n-n}
\end{aligned}$$

And

$$\begin{aligned}
D_e = {} & D_i(k^{n-1} + k^{n-2} + \ldots + k^{n-(n-3)} + k^{n-(n-1)}) \\
& + D_a(k^{n-2} + k^{n-4} + \ldots + k^{n-(n-2)} + 1),
\end{aligned}$$

or:

$$\begin{aligned}
D_e = {} & D_i k(k^{n-2} + k^{n-4} + \ldots + k^{n-(n-2)} + k^{n-n}) \\
& + D_a(k^{n-2} + k^{n-4} + \ldots + k^{n-(n-2)} + 1) \quad (3)
\end{aligned}$$

The series in the parentheses of Equation (3) are geometrical; the first term is 1, the common factor is k^2, and there are $n/2$ terms in each. Thus:

$$D_e = D_i k\left\{\frac{1 - (k^2)^{n/2}}{1 - k^2}\right\} + D_a\left\{\frac{1 - (k^2)^{n/2}}{1 - k^2}\right\}$$

or

$$D_e = \{D_i k + D_a\}\left\{\frac{1 - k^n}{1 - k^2}\right\} \quad (n \text{ even}) \quad (4)$$

Equations (2) and (4) give a means of calculating the effective dose in double field work as, for example, in abdominal radiation. A roentgen dose of r units may be applied to the posterior and anterior sides of the abdomen on alternate days, respectively. When the anterior side is radiated, the posterior receives a dose μr, where μ denotes the percentage of the beam that remains after it has passed through the body. Similarly, when the posterior side is radiated, the anterior receives a dose μr. Thus, if treatment is started by giving the anterior side a dose of r (roentgens) the first day, and is continued by giving the same dose on the posterior side the second day, etc., the effective dose for the anterior side just after the dose has been given on the nth day is:

$$D_e = \{rk + \mu r\}\left\{\frac{1 - k^n}{1 - k^2}\right\} \quad (n \text{ even})$$
$$= r\left\{\frac{1 - k^{n+1}}{1 - k^2}\right\} + \mu kr\left\{\frac{1 - k^{n-1}}{1 - k^2}\right\} \quad (n \text{ odd})$$

There is a similar set of equations for the posterior side:

$$D_e = \{\mu rk + r\}\left\{\frac{1 - k^n}{1 - k^2}\right\} \quad (n \text{ even})$$
$$= \mu r\left\{\frac{1 - k^{n+1}}{1 - k^2}\right\} + rk\left\{\frac{1 - k^{n-1}}{1 - k^2}\right\} \quad (n \text{ odd})$$

Equations (2) and (4) may be used also to calculate the effective dose at various depths by giving D_i and D_a in terms of the appropriate percentages of the primary beam. The use of these equations assumes, of course, that tissue at various depths possesses the property of recovery mentioned above.

If dosage is stopped, the effective dose, D_e, will diminish as the tissues recover. On the first day after dosage is stopped, the effective dose will be D_ek; on the second day it becomes D_ek^2, and on the pth day it becomes D_ek^p. In practice it may happen that dosage is given throughout the week except for Saturday and Sunday; and thus for several weeks in succession. In double-field work of this kind, the effective dose for the anterior for the week is

$$D_e = r\left\{\frac{1 - k^{n+1}}{1 - k^2}\right\} + \mu kr\left\{\frac{1 - k^{n-1}}{1 - k^2}\right\} \quad n = 5.$$

This will depreciate to D_ek^3 over the week-end (since Monday is the third day after Friday). If dosage is resumed on that Monday and continued in this intermittent fashion for w weeks, the total effective dose for the period will be:

$$D_{et} = D_ek^3k^{7(w-1)} + D_ek^3k^{7(w-2)} + D_ek^3k^{7(w-3)} + \ldots + D_ek^3$$
$$= D_ek^3(k^{7(w-1)} + k^{7(w-2)} + k^{7(w-3)} + \ldots + 1) \tag{5}$$

The series in the parentheses is a geometrical progression of which the first term is 1, the common factor k^7, and the number of terms is w.

$$\therefore D_{et} = D_ek^3\left\{\frac{1 - k^{7w}}{1 - k^7}\right\} \tag{5.1}$$

Thus if dosage is given alternately, as described above, from Monday to Friday and resumed in exactly the same manner the following Monday, for w weeks, Equation (5.1) gives the total effective dose at the beginning of the Monday w weeks later.

If, in Equations (2) and (4), we let $D_i = D_a = D$, we have n even,

$$D_e = \{Dk + D\}\left\{\frac{1 - k^n}{1 - k^2}\right\} =$$
$$D(k + 1)\left\{\frac{1 - k^n}{1 - k^2}\right\} = D\left\{\frac{1 - k^n}{1 - k}\right\}$$

n odd,

$$D_e = D\left\{\frac{1 - k^{n+1}}{1 - k^2}\right\} + kD\left\{\frac{1 - k^{n-1}}{1 - k^2}\right\} =$$
$$\frac{D}{1 - k^2}(1 + k - k^n - k^{n-1}) = D\left\{\frac{1 - k^n}{1 - k}\right\}$$

Thus, the expressions for D_e for n even and for n odd become identical when the alternating doses become identical. In other words, if the same dose is given for n days, the effective dose is:

$$D_e = D\left\{\frac{1 - k^n}{1 - k}\right\} \tag{8}$$

If the dose is given every other day, our k becomes k^2; if it is given every third day, k becomes k^3; if it is given every mth day, k becomes k^m. Likewise, n becomes $(n - 1)/2$, $(n - 2)/3$,... $[n + (m - 1)]/m$. Substituting in (8),

$$D_e = D\left\{\frac{1 - (k^m)^{[n+(m-1)]/m}}{1 - k^m}\right\} = D\left\{\frac{1 - k^{n+m-1}}{1 - k^m}\right\} \tag{9}$$

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IT is found that tissue exhibits a property of "recovery from radiation effects." The rate of recovery is generally assumed to be exponential (1 and 2). Due to this property of recovery, the effective radiation dose (sometimes called cumulative) tends toward an equilibrium value, that is, a value at which the rate of recovery of the tissue equals the rate of dosage.

Assuming the fact of tissue recovery we will derive an expression for the effective (or cumulative) dose at the time just after it has been administered on the nth day. Since recovery begins the moment energy is absorbed by the tissue, we shall, for a first approximation, assume that the dose is administered instantaneously. To cover cases in which different doses are given on alternate days we shall take the case wherein D_i, the initial dose, alternates with a dose D_a on subsequent days. Let β be the recovery factor of the tissue for unit time. Thus β may be 4 per cent per day (3) as in the case of radium radiation filtered through 1 mm. of platinum, or it may be 8 per cent per day (2) as in the case of roentgen radiation of $\lambda_{\text{eff}} = 0.16$ Å. Let $k = (1 - \beta)$, or the amount of radiation effect remaining after one day.

First there is the case when n is odd. The contribution of the first day, A_1, to the effective dose will be $D_i k^{n-1}$; the contribution of the second day, B_2, will be $D_a k^{n-2}$, etc. Thus:

$$\begin{aligned}
A_1 &= D_i k^{n-1} \\
B_2 &= D_a k^{n-2} \\
A_3 &= D_i k^{n-3} \\
B_4 &= D_a k^{n-4} \\
&\vdots \\
B_{n-3} &= D_a k^{n-(n-3)} \\
A_{n-2} &= D_i k^{n-(n-2)} \\
B_{n-1} &= D_a k^{n-(n-1)} \\
A_n &= D_i k^{n-n}
\end{aligned}$$

The effective dose after n days is equal to the sum of the A's and B's. But:

$$\begin{aligned}
{}_1\Sigma A_j &= D_i(k^{n-1} + k^{n-3} + k^{n-5} + \ldots + k^{n-(n-2)} + 1) \quad (1) \\
{}_1\Sigma B_j &= D_a(k^{n-2} + k^{n-4} + k^{n-6} + \ldots + k^{n-(n-3)} + k) \\
&= D_a k(k^{n-1} + k^{n-3} + k^{n-5} + \ldots + k^{n-(n-2)} + 1) \quad (1.1)
\end{aligned}$$

The series in the right-hand sides of Equations (1) and (1.1) are geometrical progressions of which the first term a is equal to 1; the common factor $d = k^2$, and the number of terms are $z = (n + 1)/2$. The sum of such a progression is $S = \dfrac{a - ad^z}{1 - d}$.

Hence for the above series:

$${}_1\Sigma A_j = D_i\left\{\frac{1 - k^{2(n+1)/2}}{1 - k^2}\right\} \qquad {}_1\Sigma B_j = D_a k\left\{\frac{1 - k^{2(n-1)/2}}{1 - k^2}\right\}$$

The effective dose, D_e, is then

$$D_e = D_i\left\{\frac{1 - k^{n+1}}{1 - k^2}\right\} + kD_a\left\{\frac{1 - k^{n-1}}{1 - k^2}\right\} \quad (n \text{ odd}) \quad (2)$$

When n is even, the contribution of the first day, A_1, is $D_i k^{n-1}$; that of the second day, B_2, is $D_a k^{n-2}$, etc., whereas:

$$\begin{aligned}
A_{n-3} &= D_i k^{n-(n-3)} \\
B_{n-2} &= D_a k^{n-(n-2)} \\
A_{n-1} &= D_i k^{n-(n-1)} \\
B_n &= D_a k^{n-n}
\end{aligned}$$

And

$$\begin{aligned}
D_e = {} & D_i(k^{n-1} + k^{n-2} + \ldots + k^{n-(n-3)} + k^{n-(n-1)}) \\
& + D_a(k^{n-2} + k^{n-4} + \ldots + k^{n-(n-2)} + 1),
\end{aligned}$$

or:

$$\begin{aligned}
D_e = {} & D_i k(k^{n-2} + k^{n-4} + \ldots + k^{n-(n-2)} + k^{n-n}) \\
& + D_a(k^{n-2} + k^{n-4} + \ldots + k^{n-(n-2)} + 1) \quad (3)
\end{aligned}$$

The series in the parentheses of Equation (3) are geometrical; the first term is 1, the common factor is k^2, and there are $n/2$ terms in each. Thus:

$$D_e = D_i k\left\{\frac{1 - (k^2)^{n/2}}{1 - k^2}\right\} + D_a\left\{\frac{1 - (k^2)^{n/2}}{1 - k^2}\right\}$$

or

$$D_e = \{D_i k + D_a\}\left\{\frac{1 - k^n}{1 - k^2}\right\} \quad (n \text{ even}) \quad (4)$$

Equations (2) and (4) give a means of calculating the effective dose in double field work as, for example, in abdominal radiation. A roentgen dose of r units may be applied to the posterior and anterior sides of the abdomen on alternate days, respectively. When the anterior side is radiated, the posterior receives a dose μr, where μ denotes the percentage of the beam that remains after it has passed through the body. Similarly, when the posterior side is radiated, the anterior receives a dose μr. Thus, if treatment is started by giving the anterior side a dose of r (roentgens) the first day, and is continued by giving the same dose on the posterior side the second day, etc., the effective dose for the anterior side just after the dose has been given on the nth day is:

$$D_e = \{rk + \mu r\}\left\{\frac{1 - k^n}{1 - k^2}\right\} \qquad (n \text{ even})$$
$$= r\left\{\frac{1 - k^{n+1}}{1 - k^2}\right\} + \mu kr\left\{\frac{1 - k^{n-1}}{1 - k^2}\right\} \quad (n \text{ odd})$$

There is a similar set of equations for the posterior side:

$$D_e = \{\mu rk + r\}\left\{\frac{1 - k^n}{1 - k^2}\right\} \qquad (n \text{ even})$$
$$= \mu r\left\{\frac{1 - k^{n+1}}{1 - k^2}\right\} + rk\left\{\frac{1 - k^{n-1}}{1 - k^2}\right\} \quad (n \text{ odd})$$

Equations (2) and (4) may be used also to calculate the effective dose at various depths by giving D_i and D_a in terms of the appropriate percentages of the primary beam. The use of these equations assumes, of course, that tissue at various depths possesses the property of recovery mentioned above.

If dosage is stopped, the effective dose, D_e, will diminish as the tissues recover. On the first day after dosage is stopped, the effective dose will be D_ek; on the second day it becomes D_ek^2, and on the pth day it becomes D_ek^p. In practice it may happen that dosage is given throughout the week except for Saturday and Sunday; and thus for several weeks in succession. In double-field work of this kind, the effective dose for the anterior for the week is

$$D_e = r\left\{\frac{1 - k^{n+1}}{1 - k^2}\right\} + \mu kr\left\{\frac{1 - k^{n-1}}{1 - k^2}\right\} \qquad n = 5.$$

This will depreciate to D_ek^3 over the week-end (since Monday is the third day after Friday). If dosage is resumed on that Monday and continued in this intermittent fashion for w weeks, the total effective dose for the period will be:

$$D_{et} = D_ek^3k^{7(w-1)} + D_ek^3k^{7(w-2)} + D_ek^3k^{7(w-3)} + \ldots + D_ek^3$$
$$= D_ek^3(k^{7(w-1)} + k^{7(w-2)} + k^{7(w-3)} + \ldots + 1) \tag{5}$$

The series in the parentheses is a geometrical progression of which the first term is 1, the common factor k^7, and the number of terms is w.

$$\therefore D_{et} = D_ek^3\left\{\frac{1 - k^{7w}}{1 - k^7}\right\} \tag{5.1}$$

Thus if dosage is given alternately, as described above, from Monday to Friday and resumed in exactly the same manner the following Monday, for w weeks, Equation (5.1) gives the total effective dose at the beginning of the Monday w weeks later.

If, in Equations (2) and (4), we let $D_i = D_a = D$, we have n even,

$$D_e = \{Dk + D\}\left\{\frac{1 - k^n}{1 - k^2}\right\} =$$
$$D(k + 1)\left\{\frac{1 - k^n}{1 - k^2}\right\} = D\left\{\frac{1 - k^n}{1 - k}\right\}$$

n odd,

$$D_e = D\left\{\frac{1 - k^{n+1}}{1 - k^2}\right\} + kD\left\{\frac{1 - k^{n-1}}{1 - k^2}\right\} =$$
$$\frac{D}{1 - k^2}(1 + k - k^n - k^{n-1}) = D\left\{\frac{1 - k^n}{1 - k}\right\}$$

Thus, the expressions for D_e for n even and for n odd become identical when the alternating doses become identical. In other words, if the same dose is given for n days, the effective dose is:

$$D_e = D\left\{\frac{1 - k^n}{1 - k}\right\} \tag{8}$$

If the dose is given every other day, our k becomes k^2; if it is given every third day, k becomes k^3; if it is given every mth day, k becomes k^m. Likewise, n becomes $(n - 1)/2$, $(n - 2)/3$,... $[n + (m - 1)]/m$. Substituting in (8),

$$D_e = D\left\{\frac{1 - (k^m)^{[n+(m-1)]/m}}{1 - k^m}\right\} = D\left\{\frac{1 - k^{n+m-1}}{1 - k^m}\right\} \tag{9}$$

This gives the total effective dose on the nth day just after the dose has been administered, the dose D having been given every mth day for the n days.

It is frequently desirable to know how long it will take a given method of dosage to reach the so-called equilibrium state. Theoretically this condition is never attained. There is, however, a condition attained in which the daily incremental dose contributes a negligibly small amount to the effective dose. For practical purposes this may be taken as the equilibrium condition. Consider the case described by Equation (9). The increment of effective dose is given by

$$(D_e k^m + D) - D_e = cD \quad (0 < c < 1)$$

Substituting the value of D_e, we have

$$\left[D\left\{\frac{1 - k^{n+m-1}}{1 - k^m}\right\}k^m + D\right] - D\left\{\frac{1 - k^{n+m-1}}{1 - k^m}\right\} = cD$$

Dividing and multiplying by D and $(1 - k^m)$, respectively,

$$(1 - k^{n+m-1})k^m + 1 - k^m - 1 + k^{n+m-1} = c(1 - k^m)$$

$$k^{n+m-1} = c \tag{10}$$

$$n = \frac{\log c}{\log k} - (m - 1) \tag{10.1}$$

Since $0 < c < 1$ and $0 < k < 1$, it is evident that $\frac{\log c}{\log k}$ is always a positive number. An important feature of Equation (10) is that for a given c, the value of n is independent of the daily incremental dose D; n depends primarily on k, and to a lesser extent on m.

Consider Equations (2) and (4). Let $D_a = D_i t = tD$, where $0 < t < 1$. In the following discussion we have only to consider the case wherein $0 < t < 1$, for, when $t = 1$, we have the case taken up in Equations (9) and (10); and when $t > 1$, we have only to consider the last $(n - 1)$ terms of the dosage series since they will form a series in which $0 < t < 1$. The increment of effective dose for the time between successive odd numbered days expressed as a fraction of D is given by

$$[(D_e k + tD)k + D] - D_e = cD$$

Substituting the value of D_e from Equation (2) and clearing of fractions we arrive at the following:

$$k^n(k + t) = c \tag{11}$$

$$n = \frac{\log c - \log (k + t)}{\log k} \tag{11.1}$$

Corresponding expressions for the interval between even numbered days will be found to be:

$$k^n = \frac{ct}{k + t}$$

$$n = \frac{\log ct - \log (k + t)}{\log k}$$

The equations pertaining to the increment of effective dose that accrues in the interval between odd numbered days (11) and (11.1), are more important, as it will be seen from Figure 1 that the effective dose is generally at a maximum on odd numbered days. Figure 1 shows the typical behavior of effective dose when alternate doses are given. The dotted lines indicate the course of depreciation as the tissue recovers. Curves (*a*) and (*b*) are lines drawn through the values of the effective dose on odd numbered and on even numbered days, respectively.

It is to be observed that when alternating doses are given, the time required to reach a state of equilibrium is a function of the ratio of the doses, t, and of $(k + t)$.

APPLICATIONS

For those who are interested primarily in the practical applications of these equations rather than in the mathematical derivations the following examples are presented.

1. Suppose a tumor on the right side of the neck is to be treated with roentgen radiation, $\lambda_{eff} = 0.16$ Å. Two hundred r units are to be given the right side on the first day, the same amount to the left side the following day, etc., and thus alternated for 11 days. What will be the effective dose on the eleventh day after the dose has been administered on that day? Suppose the neck depreciates the primary beam 70 per cent, that is, 30 per cent

comes through. Since 11 is odd, we use Equation (2):

$$D_e = D_i \left\{\frac{1 - k^{n+1}}{1 - k^2}\right\} + kD_a \left\{\frac{1 - k^{n-1}}{1 - k^2}\right\}$$

By means of Equation (11) the fraction of the dose that will be added to the effective dose on the thirteenth day may be determined.

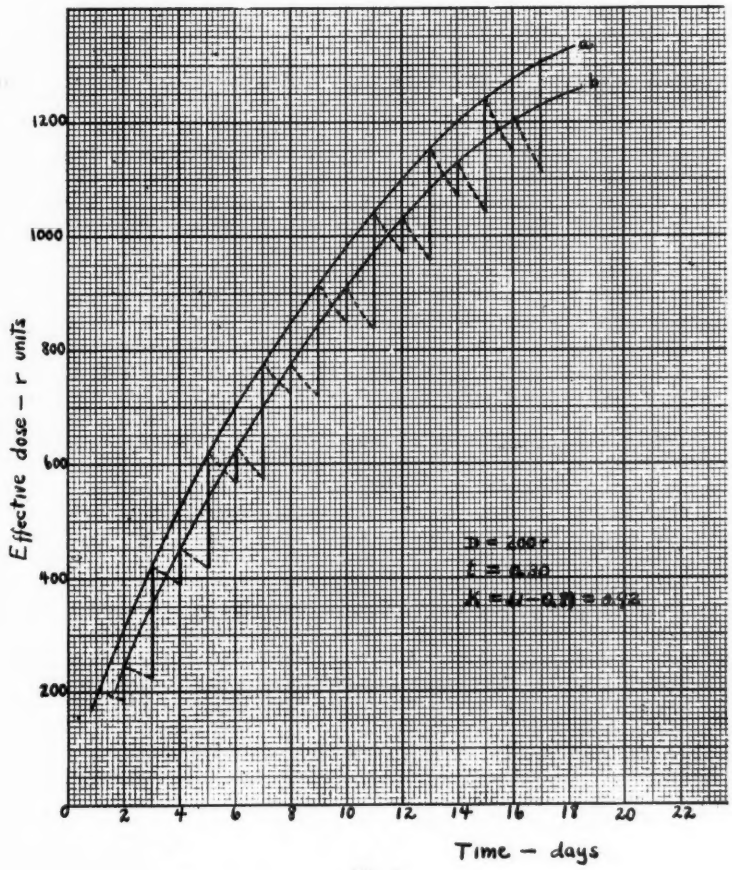

Fig. 1.

For roentgen radiation $\lambda_{eff} = 0.16$ Å., $\beta = 0.077$ per day. Hence $k = (1 - 0.077) = 0.923$ per day. D_i, the initial dose, = 200 r; and D_a, the alternating dose, = 200 r × 0.3 = 60 r. Thus, substituting:

$$D_e = 200\ r \left\{\frac{1 - (0.923)^{11+1}}{1 - (0.923)^2}\right\} + (0.923)\ (60\ r) \left\{\frac{1 - (0.923)^{11-1}}{1 - (0.923)^2}\right\}$$

$$= 200\ r \left(\frac{0.621}{0.149}\right) + 55.4\ r \left(\frac{55.4}{0.149}\right) =$$

$$200\ r\ (4.17) + 55.4\ r\ (3.71)$$

= 1040 r (to within the error of slide-rule reading).

$$c = k^n(k + l) = (0.923)^{11}(0.923 + 0.3)$$

$$= (0.412)\ (1.223) = 0.504$$

meaning that 50.4 per cent of the dose on the thirteenth day will be added to the effective dose, or c(200 r) = 0.504 (200 r) = 100.8 r. And the effective dose on the thirteenth day will be 1,038 r + 100.8 r = 1,138.8 r.

Or we may find the time at which only 10 per cent of the daily dose is added toward the effective dose. Using Equation (11.1),

$$n = \frac{\log c - \log (k + t)}{\log k} = \frac{\log 0.1 - \log (0.923 + 0.3)}{\log 0.3}$$

$$= \frac{-1 - (0.08743)}{-0.0348} = \frac{1.08743}{0.0348} = 31.2 \text{ or } 31 \text{ days}$$

meaning that on the thirty-third day only 10 per cent of the 200 r will be added toward the effective dose.

2. Suppose that radium radiation filtered through 1 mm. of platinum is given in doses of 3,000 mg.-hr. every second day. What will be the effective dose after 21 days, and what percentage of the dose will be added to the effective dose on the twenty-third day? The effective dose is given by Equation (9):

$$D_e = D \left\{ \frac{1 - k^{n+m-1}}{1 - k^m} \right\}$$

D = 3,000 mg.-hr.; β = 0.04 per day; hence k = (1 − 0.04) = 0.96; m = 2; n = 21.

$$D_e = 3{,}000 \left\{ \frac{1 - (0.96)^{21+2-1}}{1 - (0.96)^2} \right\} = 3{,}000 \left(\frac{0.59}{0.078} \right)$$

$$= 22{,}680 \text{ mg.-hr.}$$

Equation (10) enables us to find c,

$$k^{n+m-1} = c$$

$$(0.96)^{21+2-1} = c = (0.96)^{22} = 0.4099 = 0.41.$$

Thus 41 per cent of the dose, or 1,230 mg.-hr., will be added to the effective dose of the twenty-first day to give the effective dose of the twenty-third day (22,680 + 1,230 = 23,910 mg.-hr.). Conversely, we may find the time at which only 10 per cent of the daily dose will be added to the effective dose. Using Equation (10.1),

$$n = \frac{\log c}{\log k} - (m - 1) = \frac{\log 0.1}{\log 0.96} - (2 - 1)$$

$$= \frac{-1}{-0.0177} - 1 = 56.5 - 1 = 55^{+} \text{ days},$$

meaning that on the fifty-seventh day only 10 per cent of the daily dose will be added toward the effective dose.

SUMMARY

1. A general expression is derived for the effective dose after n days, the dosage consisting of two doses that alternate from day to day. Equations (2) and (4).

2. The alternating doses are made equal to one another. The resulting expression gives the effective dose when the same dose is given for n days. This is then generalized to the case wherein the same dose is given every mth day for n days. Equation (9).

3. It is then shown that the time required for a given method of dosage (using a single dose of the same value each time) to reach an approximate state of equilibrium *is independent of the daily dose.* Equation (10).

4. When, however, two different doses alternate from day to day, it is found that the time required for the attainment of the equilibrium state is dependent on the ratio of the two doses. Equations (11) and (11.1).

5. Practical applications of the formulæ are given.

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A STUDY OF BACK-SCATTER FOR SEVERAL QUALITIES OF ROENTGEN RAYS[1]

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IT is a well-known fact that when a beam of radiation strikes matter, some of the rays are scattered in all directions. The amount of scatter depends upon the quality of the radiation, the nature of the material upon which it impinges, the volume of the material, and the area of the beam. The relative amount of scattered radiation is different in different directions, being greatest in the forward and least in the backward direction.

The portion scattered backward is of particular interest in radiation therapy, because of its contribution to the dose delivered at the surface of the body. This dose consists, in part, of radiation from the primary beam, and, in part, of that scattered back by the underlying tissues. Since all depth doses are determined in relation to the surface dose, it is necessary to know this accurately. Moreover, it is not possible to determine the erythema dose in terms of physical units (roentgens) until the intensity of a beam as measured in air can be related to that on the surface of the body.

Many attempts have been made to measure the back-scatter experimentally, by means of ionization chambers, photographic films, biological media, etc., placed upon the surfaces of water, paraffin, and the human body itself. The results obtained have disagreed widely. Most of the differences may be explained by variations in experimental conditions. This is particularly true in the case of physical measurements, in which instance the nature and material of the ionization chamber are extremely important. When approximately the same experimental conditions are used, there is fair agreement in the results obtained. The method of choice so far has been the use of the small ionization chamber of organic materials, the assump-

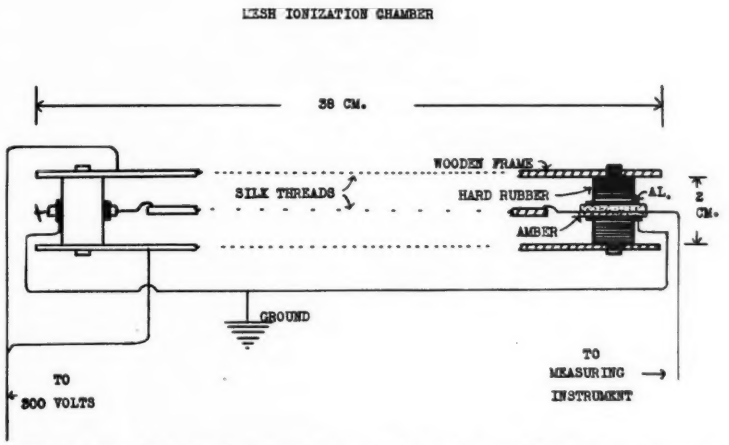
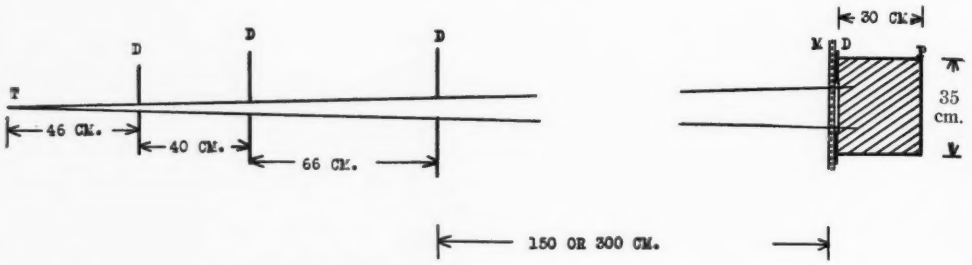


Fig. 1. Special ionization chamber, with electrodes consisting of three layers of very fine gauze impregnated with India ink.

[1] Presented at the Fourth International Congress of Radiology, Zürich, 1934.

tion being that its walls have no effect on the results. Some of these chambers, when calibrated against a standard open aluminum tube is inserted; fitted tightly into each of these tubes is an amber insulator. Through the center of each of these



T - TARGET OF X-RAY TUBE
D - D - D - D - LEAD DIAPHRAGMS
M - IONIZATION CHAMBER, CONSISTING OF THREE LAYERS OF VERY FINE SILK GAUZE IMPREGNATED WITH INDIA INK
P - LEAD-LINED ALUMINIUM POT FILLED WITH PARAFFIN

Fig. 2. Diagram of set-up for studying back-scatter from paraffin, with x-rays.

air chamber, agree with it over a wide range of quality of radiation. However, the scattered radiation contains components of very long wave length, which may be more or less completely absorbed in the walls of the chamber. At the same time, the secondary radiation from these walls and from the inner electrode may introduce a disturbing factor.

The observations here reported were made with a new type of ionization chamber, which is shown diagrammatically in Figure 1. This consists of three parallel plates, about 40 cm. square, of which the two outer ones are made of very fine silk net, impregnated with India ink, while the inner is of fine silk threads, similarly treated, stretched 1 cm. apart. The net, when inked and ready for use, weighs 14 mg. per 100 sq. cm.; this is about one-third the weight of cellophane. The frame for each plate is a square of four strips of very light wood, 1 cm. wide and 2.5 mm. thick, painted with India ink. The two outer ones are maintained 2 cm. apart by plugs of hard rubber at the four corners, and are charged to 300 volts by dry batteries. Through each of these rubber plugs, as shown in the diagram, a small insulators passes a fine copper wire, which is connected to one corner of the frame carrying the threads which form the inner plate. These wires form the support of this plate, and one of them serves as the lead to the measuring instrument. The four aluminum shields of the amber insulators are grounded, thus furnishing an effective guard ring. The chamber is held in the path of the beam of radiation by means of clips of hard rubber which hold the wooden frame and are attached to a firm support. No part of the wooden frame or any of the outside support ever comes into the path of the beam.

All ionization measurements were made with the vacuum tube instrument of Failla. This has an extremely wide range of sensitivity, and is much faster than any electroscope or electrometer. It is, therefore, possible to make many readings in the course of an experimental run, even when the intensities of the radiations are low, thus permitting careful checking of results.

The general arrangement of the apparatus is shown diagrammatically in Figure 2. X-rays were generated at voltages from 80 to 185 K.V. peak by a simple Vil-

lard circuit. The size of the beam reaching the chamber was regulated by three lead diaphragms, one in the tube holder and two outside it, their distances from the target being 46, 86, and 152 cm., respectively. For the measurement of the primary radiation, the diaphragm shown behind the chamber, and the scattering unit were removed. This scattering unit consists of an aluminum pot 30 cm. deep and 35 cm. in diameter, lined with 3 mm. of lead and then filled with paraffin. The purpose of the lead is to prevent radiation scattered by the paraffin from emerging, striking the walls, and giving rise to disturbing radiation. When this scattering mass was placed behind the chamber, radiation scattered backward was registered in the ionization current. The diaphragm between the paraffin and the chamber was placed there in order to stop rays scattered obliquely backward out of the beam, since it was desired to measure only radiation scattered back within the irradiated area. The opening in this diaphragm was slightly larger than the actual beam.

Fig. 3. Photograph of apparatus for studying back-scatter with x-rays.

The actual set-up is shown in Figure 3. Diaphragms, chamber, and scattering element were mounted on rails so that they were properly centered at all times. As mentioned above, the third collimating diaphragm was 152 cm. from the target. The ionization chamber was either 300 or 450 cm. from the target. The various filters used were placed in the first diaphragm, which is in the tube holder. For the 300 cm. distance, the scattering element could be rolled 200 cm. farther back on the rails, when no effect could be detected from it. For the 450 cm. distance it was necessary to remove the pot from the runway. The primary beam was never large enough to strike the wooden framework of the runway within 200 cm. of the chamber. Walls, floor, and ceiling were always more than 200 cm. from the chamber, except at the 450 cm. distance, when the floor was only 150 centimeters. The rear wall, the only one which could be struck by the primary beam, was always at least 300 cm. away.

The centering of the beam with regard to diaphragms and chambers was always checked photographically. A film placed just in front of the chamber, and another just behind the rear diaphragm, showed accurately the size and shape of the beam and the clearance of the rear diaphragm.

With large beams it was not possible to

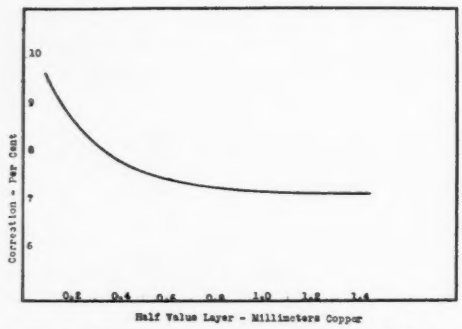


Fig. 4. Curve showing correction for space between paraffin scattering element and ionization chamber.

eliminate entirely the stem radiation, even with the three diaphragms. This showed as a very slight haze on one side of the test film. Such radiation, being outside the beam which passed through the aperture of the rear diaphragm, would strike this lead and send scattered radiation of its own into the chamber. This proved never to be more than a few per cent of the total scatter, but was measured for every diaphragm and every quality of radiation, so that the proper correction could be made.

There was a possibility that scattered radiation striking the edges of the lead diaphragm might give rise to secondary rays of the electron type, which would increase the ionization supposedly due to scattered rays from the paraffin. In order to eliminate this, the diaphragms were coated with a celluloid solution to a distance of 2 cm. from the aperture, on both sides. This made no difference in the readings, showing that such radiation did not occur in sufficient quantity to be considered.

Between the surface of the paraffin and the surface of the chamber was an air space of 1 cm., the lead diaphragm being in contact with the paraffin. In this air, some of the softest scattered and secondary rays were absorbed. The method of correcting for this was as follows: After the routine measurements with and without diaphragm and paraffin had been made, the paraffin was moved back from the chamber, a short distance at a time, a reading being taken for each position. A curve was then drawn showing decrease in radiation with increase in distance, and this was extrapolated back to the position of the surface of the chamber. Since the rate of change in intensity was not large, and the distance covered by the extrapolation only 1 cm., such a method of correction is legitimate. This extrapolated value was used as the correct reading for the total radiation, including back-scatter. The correction was never large, and was independent of the field, within the limits investigated. It varied somewhat with the quality of the radiation, as shown in Figure 4.

Measurements of scattered radiation were first made at 185 K.V. peak, with filters of 0.16, 0.48, 1.03, and 2.06 mm. of copper, corresponding to half value layers in copper of 0.55, 0.87, 1.12, and 1.34 mm., for a range of fields from 50 to 400 sq. cm., at each of the two distances for the ionization chamber. All of these experiments were repeated at least four times, the data presented being the average of these results.

For the calculation of the percentage back-scatter for any particular case, the procedure was as follows: Four readings were taken; (1) with the diaphragm completely closed, to obtain a correction for stray radiation and for the natural leak of the chamber; (2) with the proper filter in the diaphragm, with the ionization chamber in position, but without rear diaphragm or scattering unit, to obtain the value for the primary beam; (3) with the rear diaphragm in place, to obtain a correction for radiation scattered from it, which might otherwise be included in the scatter from the paraffin; (4) with the paraffin in place, to obtain the total radiation including back-scatter. All readings were corrected for the leak and stray radiation. The reading with paraffin was corrected for the air space between it and the chamber. The scattered radiation was taken as the difference between this corrected reading for the paraffin and the

reading with the diaphragm alone. This value for the scattered radiation, divided by the value for the primary beam, gives the percentage of back-scatter. If the primary beam be called 100 per cent in each case, the percentage value for the total radiation will be 100 plus the back-scatter percentage.

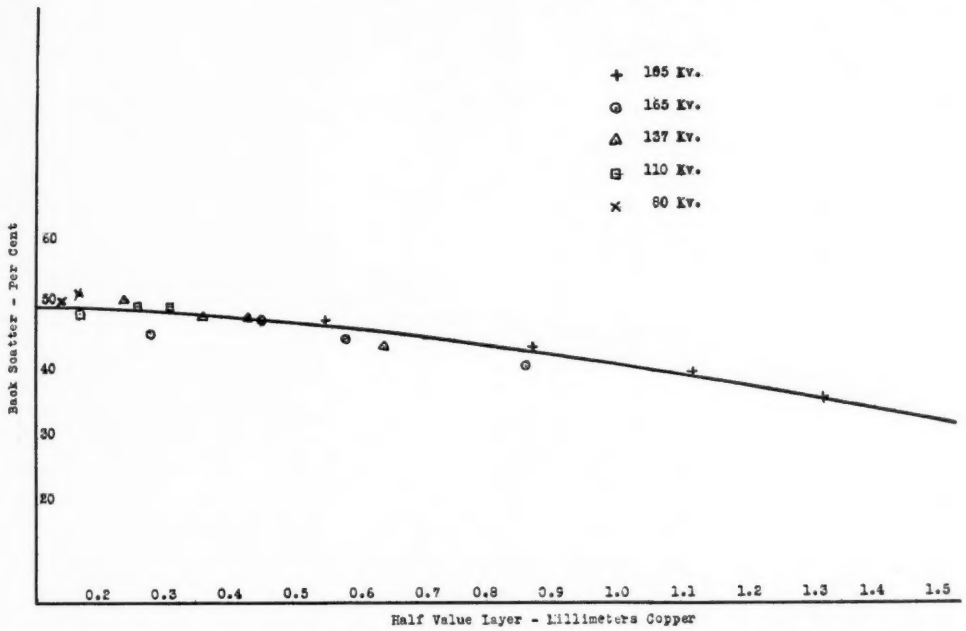


Fig. 5. Curve showing percentage back-scatter in a 78 sq. cm. field, for x-rays over a wide range of quality.

For each distance of the chamber, curves were drawn showing the relation of back-scatter to size of field, for the four qualities of radiation tested. For a given field, the values at the two distances were found to agree as well as two sets of values at the same distance. The data were, therefore, all combined, and the distance considered immaterial, provided it was great enough so that scattered radiation passing back through the chamber did not strike the diaphragms and give rise to a second scattered beam, which might return to the chamber.

The results of this series of experiments are presented in Table I. The values obtained for back-scatter are considerably higher than most of those reported in the literature as having been measured with small, so-called "air wall" chambers. The amount of scatter increases steadily with size of field and with decrease in half value layer.

TABLE I.—TOTAL RADIATION INCLUDING BACK-SCATTER FROM PARAFFIN

185 K.V. Peak (Kenetron Rectification)
Various Filters and Fields

Area of Beam	Filter—mm. Copper			
	0.16	0.48	1.03	2.06
	Half Value Layer—mm. Copper			
	0.55	0.87	1.12	1.34
Sq. cm.	Total Radiation—Per Cent (Primary Beam = 100 Per Cent)			
50	143	140	136	132
75	148	144	140	136
100	154	150	146	142
150	160	156	152	148
200	166	162	158	154
300	176	172	167	162
400	182	178	175	171

The effect of variation of radiation with variation in field or in filter may be considered independently. The effect on the

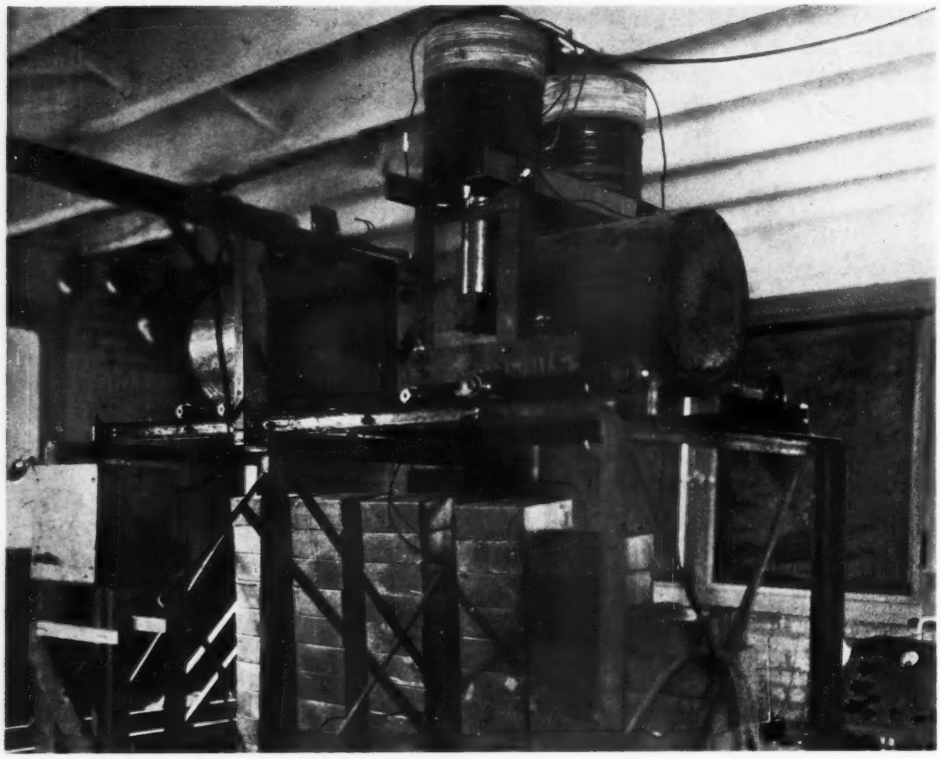


Fig. 6. Photograph of apparatus for studying back-scatter with gamma rays.

total radiation of change in quality of the beam, for any given field, may be investigated by setting the value for some one particular quality as 100 per cent, and expressing the others in terms of it. This is done in Table II for each field, the value for the 0.48 mm. copper filter being taken as 100 per cent in every case. From this table it is evident that the change in relative total radiation with change in quality is independent of the field.

In a similar way the variation with field may be studied for each quality. In Table III, the value for the 100 square centimeter field is set as 100 per cent, for each quality of radiation. It is seen that the change in intensity of radiation is independent of the quality.

The entire range of quality considered thus far is not great. A single voltage setting on the x-ray machine was used, and the quality varied by changing filters. It was, however, desirable to carry the study through a much greater range of quality. This was done for a field of 78 sq. cm. (a 10 cm. circle) for various voltages and filters, giving a complete range of

TABLE II.—VARIATION IN TOTAL RADIATION (INCLUDING BACK-SCATTER) WITH QUALITY FOR FIELDS OF DIFFERENT SIZES

185 K.V. Peak (Kenetron Rectification)

Area of Beam	Filter—mm. Copper			
	0.16	0.48	1.03	2.06
	Half Value Layer—mm. Copper			
	0.55	0.87	1.12	1.34
Sq. cm.	Total Radiation—Per Cent			
50	102	100	97	94
75	103	100	97	94
100	103	100	97	95
150	103	100	97	95
200	102	100	97	95
300	102	100	97	94
400	102	100	98	95

half value layers from 1.34 to 0.12 mm. of copper. This was the minimum which could be obtained with the x-ray machine available, using 80 K.V. and no filter. The actual beams used are specified in Table IV.

TABLE III.—VARIATION IN TOTAL RADIATION (INCLUDING BACK-SCATTER) WITH FIELD FOR DIFFERENT QUALITIES OF RADIATION

185 K.V. Peak (Kenetron Rectification)

Area of Beam	Filter—mm. Copper			
	0.16	0.48	1.03	2.06
	Half Value Layer—mm. Copper			
Sq. cm.	0.55	0.87	1.12	1.34
	Total Radiation—Per Cent			
50	93	93	93	93
75	96	96	96	96
100	100	100	100	100
150	104	104	104	104
200	108	108	108	108
300	114	115	114	114
400	118	118	119	120

TABLE IV.—SPECIFICATIONS OF RADIATIONS USED FOR WIDE RANGE IN QUALITY

K.V. Peak	Filter	Half Value Layer
	Mm. Cu	Mm. Cu
185	2.06	1.34
	1.03	1.12
	0.48	0.87
	0.16	0.55
165	0.64	0.86
	0.32	0.58
	0.16	0.45
	0	0.28
137	0.64	0.64
	0.32	0.43
	0.16	0.36
	0	0.24
110	0.32	0.31
	0.16	0.26
	0	0.17
80	0.16	0.17
	0	0.12

It is evident that any given part of the quality range may be obtained by using two or three different voltages with the appropriate filters. In other words, there is overlapping in quality ranges obtained with the various voltages.

The values for back-scatter obtained with these various beams are shown in Figure 5, where they are plotted in relation to quality as expressed by half value layer in copper. Each point is the average of observations made in at least three different series. The percentage back-scatter for a given average quality of radiation is seen to be independent of the voltage, within the range of experimental error.

At the other extreme of penetration of radiation available, some measurements have been made with gamma rays. The experimental set-up is shown in Figure 6. The radon source, 300 to 500 mc., filtered by 2 mm. of brass, was placed within a large pot of lead, so that there were at least 15 cm. of lead toward the back and sides and 20 cm. toward the front, except for the cone through which the rays emerged. This was of such a size that the beam on emerging was 2.5 cm. in diameter, and at a distance of one meter, 15 cm. in diameter. Immediately upon issuing from the lead pot, the beam passed between the poles of an electromagnet, which could be used to remove the secondary beta rays.

The long range secondary beta rays liberated in the air by the gamma rays introduce serious complications, and for this reason some other approach will have to be found to this part of the problem. The back-scatter for gamma rays obtained with the method described above appears to be also higher than that obtained with the usual small chambers, but no corrections for the secondary beta ray effect just mentioned can be made at present.

A practical application of accurate measurements of back-scatter would be the specification of the number of roentgens delivered to the skin when the intensity of the beam in air is known. A statement of radiation dose in terms of the amount delivered to the tissues would be preferable to a statement of the quantity as measured in air. Present methods of measuring by means of a small ionization chamber placed on the skin are unsatisfactory because, as stated earlier in this paper, the wall effects of such chambers are unknown for the very soft scattered and secondary radiations. Before the data here given can be applied directly to

a statement of dosage, it will be necessary to test experimentally some of the values for threshold erythema doses obtained therefrom. This work is under way, and it is hoped that a report on the subject can be made soon.

SUMMARY

The back-scatter from paraffin has been measured, for a large range of fields and qualities of radiation, by a new method.

Values of percentage scatter obtained in this way are considerably higher than those obtained with so-called "air wall" ionization chambers. The scatter increases with the irradiated area and with the effective wave length of the radiation, the two effects being independent of each other.

Tables are given for the total radiation, including back-scatter, for a range of fields and qualities, for the variation in total radiation with field for any quality, and for the variation with quality for any field.

The authors wish to express their indebtedness to Dr. G. Failla, for his assistance in devising the experimental set-up, and for his constant interest and advice throughout the course of the work.

EDITORIAL

LEON J. MENVILLE, M.D., *Editor* HOWARD P. DOUB, M.D., *Associate Editor*

THE QUALIFIED SPECIALIST

In the field of medicine, groups of specialists have set machinery in motion for awarding certificates of merit to those of their number who are justly entitled to so style themselves. One of the purposes back of the movement, and the most important one in the minds of many, is to enable the specialty and those awarded certificates of qualification to maintain standing and prestige. Perhaps entirely too much is expected in that regard, particularly in view of the qualifying procedures generally adopted.

In a general way, a specialty may be defined as the application of extraordinary knowledge to a part of a large general field. In certifying to the qualifications of specialists under such a definition, enquiry is restricted very largely to the matter of "extraordinary knowledge" which under the circumstances may possibly be the only practical procedure. However, the fact should not be lost sight of that a specialty may lose caste through the operation of other factors for which the specialist may be no less accountable than he is for knowledge of his subject. As a matter of fact, loss of caste is not nearly so apt to occur through the specialist's ignorance as it is *from his failure to integrate his special knowledge with the general knowledge of the entire field of which his particular department represents a comparatively small part.* It is only by such integration that the "specialist," as understood in the definition, is clearly differentiated from the skilled workman or technician: mere knowledge has comparatively little to do with it. Failing to secure such integration, he becomes an "assistant," and no amount of "qualifying" or "labeling" or "resoluting" can change his status one iota. Such a situation is in the main responsible for the unenviable position in which some of the medical specialties now find themselves.

The medical profession as a whole is menaced by a somewhat analogous threat as regards its status. In writings on the subject we find over and over again the statement that "it is the personal relationship between physician and patient which keeps medicine a profession," a statement which is undoubtedly true. By exactly the same token, it is the personal relationship between the medical specialist and patient that keeps the specialist a respectable and respected member of that profession. Some of the specialties do not consistently maintain that relationship, and to just that extent forfeit the esteem which they mistakenly regard as an inherent right.

The practical implications of these fundamental facts should be at once apparent to the radiologist. If he is to maintain a high standing in the medical profession and in the community, he must establish a personal relationship with every patient who comes or is referred to him. In the first place, it enables him to render infinitely better service to the patient, which, apart from other considerations, is ample justification for adopting it as a routine practice. Without in any way interfering with the rights and prerogatives of others, it will enable him to build up a clientele of his own which will in the end be essential to his survival as a specialist. His colleagues in other fields will continue to refer patients to him but with the added incentive that if he doesn't they will in the course of events likely go to him anyway. Ultimately he will find himself referring about as many patients to other physicians as they refer to him and his destines will then come to be indissolubly linked with those of the profession as a whole. Then, and not until then (assuming that he has the requisite knowledge), can it be proclaimed without fear of successful contradiction, "He is a qualified specialist."

THOMAS A. GROOVER, M.D.

SHOULD THE PATIENT BE TOLD?

Those of us who are confronted with the problem of the care and treatment of patients who have malignant disease are often in a quandary as to whether or not the patient should be told of his true condition. Too frequently, relatives come to us and say, "Under no circumstances must you tell her that she has cancer; she would commit suicide." Some-

times the family physician who has been treating the patient for an ulcer of the cervix for months will refer her for treatment with the request that she be not told that a carcinoma exists. The patient has probably repeatedly asked him if she has cancer and has been emphatically informed that there is none present, even in in view of the fact that no biopsy has been done to verify or refute the statement. The consultant is really "put on the spot" at such times. He must decide whether to defer to the wishes of the patient or to those of the relatives or a fellow-practitioner who has been remiss in his duties to the patient in not taking all precautions for making an early diagnosis by modern methods. A little "white lying" on the part of the consultant at times may be justifiable when the patient is moribund, but when such a condition as carcinoma exists which not only necessitates radical surgical treatment or adequate radiation therapy and in which frequent follow-up examinations are necessary for further treatment or statistical study, it requires co-operation on the part of the patient; this necessitates telling what the condition actually is.

Imagine trying to treat a patient with diabetes, nephritis, or cardiac decompensation without telling him what he has; still, all are incurable according to a strict interpretation, but are controllable by diet, medication, and rest if the patient understands and co-operates. The profession never did get very far in its fight against tuberculosis as long as the patient was told, "You have weak lungs," or "You are in a decline," or "You have a chronic bronchitis." On the other hand, when the patient was informed that he had pulmonary tuberculosis which required isolation to keep him from infecting the rest of the family or his friends, and that sanitorium treatment with bed rest was absolutely necessary, then we began to control tuberculosis. The patient had to know and help in the battle.

The same thing applies to cancer. Many doctors seem to fear telling patients that they have carcinoma. Why this is so, is difficult to explain. When we begin to tell patients what they have instead of hiding behind some fantastic explanation of symptoms at the request of others, then will we get co-operation. We must educate not only the patient but the entire family to the fact that because a malignancy exists the patient need not consider himself to be a social outcast. Undoubtedly, the relatives are altruistic in their request for secrecy but sooner or later some "kind neighbor" will break the news if the physician does not. If confidence is to be mutual on the part of the patient and physician, then it is better that the true situation be told. In some patients the reaction might be severe at first as a few become hysterical, but in a day or two their morale will be back and co-operation will be established. Furthermore, we must not forget that these same children of the patient under consideration who have requested secrecy will some time reach the "cancer age." They will demand the truth that was withheld from their parents.

If the campaign against cancer is to be successful, it will require that the laity and the profession work together. Patients come with a straightforward story to the physician and, after a careful examination, expect a frank opinion. This examination should be thorough and, whenever possible, the opinion should be fortified by microscopic confirmation. The patient may not believe that carcinoma exists and may seek other advice, but at least the consultant will have done his duty in arriving at a correct opinion and advising suitable scientific treatment.

ORVILLE N. MELAND, M.D.
1407 South Hope St.
Los Angeles

The Editor wishes to learn the views on this problem held by the readers of Dr. Meland's Editorial, and contemplates the publication of further communications if such are sent to him.

A brief symposium on the subject may develop.

COMMUNICATIONS

A HELPFUL SUGGESTION

Perhaps it may interest some of the older members of the Society to know that normal salt solution, used as a wet dressing, has proved beneficial in one case of very stubborn inflammatory hyper-keratosis from long use of x-rays. For a great many years I have used ointments and lotions of many types and formulæ, but only within the last year have I resorted to sea water and normal salt solution, and I believe it is worthy of a trial. In my own case, I frequently go to sleep with a pair of

cotton gloves on my hands, with a little extra padding over the back of the hands and fingers, soaked with either sea water or normal saline solution. Occasionally, in between times, a little bland jelly with a lanolin base is used.

ALBERT SOILAND, M.D.

A REQUEST FROM DR. JOSEPH C. BLOODGOOD

Will any physician reading this who has a living case of giant-cell tumor for which nothing has been done, or for which there has been only irradiation five years ago, report the case, stating (*a*) the location of the tumor, (*b*) function at the time treatment began, and (*c*) function now. Also, give the name and address of the physician who reports the case, and the patient's name. The patient must be living; it must be at least five years since the beginning of treatment; there must have been a roentgen-ray diagnosis, with or without biopsy, and there must have been no treatment except irradiation.

Information is to be sent to Joseph C. Bloodgood, M.D., 3301 North Charles St., Baltimore, Md.

DR. STANLEY MELVILLE

Because of the deaths of several of our pioneer radiologists, the medical world was made to see the dangers of the practice of roentgenology. In England, in 1921, a special committee was formed for the purpose of advising on these dangers: Dr. Stanley Melville played a very prominent part in this action.

To this committee on x-ray and radium protection goes the credit for being the first in the work to draw up recommendations for safeguarding workers in this field. So valuable was their work that in 1928, the international Radiological Congress, at Stockholm, adopted their constructive ideas as a basis for their recommendations.

Dr. Stanley Melville, one of the foremost pioneer radiologists, took a most important but unobtrusive part in all that concerned medical radiology. He featured prominently in the establishment of the Diploma in Medical Radiology and Electrology (D. M. R. E.) at Cambridge, in 1919, and subsequently the teaching and examinations connected with it were his constant care. The Bi-Lingual Congress of 1922 and the First International Congress of Radiology in London, in 1925, were largely due to his initiative, as also was the formation of the British Institute of Radiology with which the Roentgen Society was eventually incorporated. His untiring energy led him to do much for the welfare of the lay worker, taking a prominent part in the foundation of the Society of Radiographers. Notwithstanding the fact that he was sadly handicapped physically, often suffering as the result of dermatitis incurred in the early days, Melville never spared himself when any work in the field of medical radiology had to be done; to be ever ready to step into the breach seemed a natural course of events.

The following eminent British radiologists are members of a committee to consider a memorial to perpetuate the name of Stanley Melville, such as a traveling fellowship in radiology or some other form of acknowledgment yet to be determined: Humphry Rolleston, Rutherford L. S. T. Burrell, G. W. C. Kaye, G. W. Mitchell, R. S. Paterson, Leo A. Rowden, Sidney Russ, J. Duncan White, and A. E. Barclay.

PROFESSOR PASQUALE TANDOJA

IN MEMORIAM

Word has been received of the death of Professor Pasquale Tandoja, an esteemed experimenter and practicer of radiology. Professor Tandoja has been for a number of years on the Foreign Advisory Staff of this Journal, and had many friends among radiologists in this country. Since the first International Congress of Radiology, in London, he had attended these gatherings, and many beside his fellow-countrymen will mourn his passing.

THE FIRST INTERNATIONAL CONGRESS OF ELECTRO-RADIOBIOLOGY

VENICE, SEPT. 10 TO 15, 1934

The International Society of Radiobiology, established through the initiative and goodwill of a few people interested in radiobiological sciences and which has been for some time developing its activity through the keen work of its Secretary, Dr. De Protti, of Venice, was constituted into an official body at the meeting of its first Congress, which took place in Venice during the month of September last.

Under the high Honorary Presidency of H. E. G. Marconi, President of Accademia d'Italia (the Academy of Italy), H. E. Conte G. Volpi di Misurata, State Minister, acting as Chairman, the Congress has carried out its works, which, owing both to the participation of famous scientists and to the importance of the subjects treated, proved of exceptional interest to all persons devoted to the study of physical, biological, and medical sciences. Among the many persons present at the meetings we should like to mention Prof. Abderhalden and Prof. Behnken as representatives for Germany, the Duca di Broglia and Prof. Kopanwski for France, Mr. Arthur Compton (Nobel prize) and Dr. Francis Carter Wood on behalf of the United States, Mr. Adrian (Nobel prize), for England, Mr. Marinescu representing Romania, Mr. Baron and Mr. Gurwitsch for Russia, and again for Italy H. E. E. Fermi and H. E. Parravano, H. E. Rondoni, all Academicians of Italy, beside a large number of scientists belonging to various learned societies.

Reports of great scientific value were then made, among which I should like to mention as of great importance those by Mr. Arthur Compton on "The Physical and Chemical Effects of Electrical Radiations"; Dr. F. C. Wood on "The Biological Effects of Ultrasounds"; Mr. C. Foà and Mr. Adrian on "The Electrical Activity of the Nervous System"; Signor Castaldi on "The Biological Effects of the Hertzian Waves"; Mr. Sakowsky on "The High Frequency Oscillators." Remarkable reports were also submitted at subsequent meetings, among which were those by Mr. Ornstein on "The Quantitative Methods of Spectrophotometry" and by Prof. Abderhalden on "The Influence of Ultra-violet Rays on Proteinaceous (?) Substances." Especially worthy of notice was the report by Prof. Gurwitsch on "The Present Stage of the Mitogenetic Problem," following which Mr. Marinescu's report dealt with "The Regeneration of Nerves as Related to Mitogenetic Radiation" and by Mr. Rahn on "Micro-organisms as Detectors of Mitogenetic Rays." Important communications were also made by Mrs. Prof. Brunetti on "Spectrography in Biology"; by Mr. E. Regener on "The Measuring of the Solar Ultra-violet Spectrum in the Stratosphere"; by Prof. Huskins on "The Latest Progress of Genetic Radiation"; by Prof. Capelli on "The Biological Action of the Roentgen Rays on Cancerous Tissues"; by Dr. Wood on "The Roentgen Sensitivity of X-rays of Individuals Submitted to Ultra-violet Irradiation"; by Sig. Foà and Sig. Galli on "The Biologic Effects of Secondary Radiations"; by Mr. Rivera on "Researches of the Radio-action on Lower and Higher Vegetative Organisms"; by Sig. Santo-Ricci on "Measuring by Means of Absorbomicrometric Scales"; by Mr. Dobrovolskaja-Savadskaja on "The Influence of X-rays on Heredity"; by Sig. Balli on "The Action of X-rays on the Cellular Elements"; by Prof. Behnken on "The Dosimetric Processes in Radiobiology"; by Sig. Pugno Vanoni on "Radio-roentgen Measurements." Special mention must also be made of the reports of Mr. Donaggio on "The Action of X-rays on the Neurofibrillous Net"; of Sig. Palmieri on the "Radiobiotanalogic (?) Phenomena"; of Prof. Scholte on "The Action of X-rays on Nervous Tissue"; of Sig. Allodi on "The Radiology of the Fascia," and of Sig. Rivera on the "Biologic Action of Metals."

At later meetings which were held at Padua University, Messrs. Regener, Compton, Blackett, Rojji, and Fermi spoke on other subjects of interest in connection with the physics of x-rays.

The communications made in connection with the reports and dealing with similar subjects submitted to the attention of the Congress, were also numerous. Such communications amply proved that the greatest attention is being given to radiobiologic problems in every country and that the interest in such problems is ever on the increase. This appeared so evident at the closing of the activity of the Congress and to such a degree that the assembly deliberated, together with the final foundation of the International Society of Radiobiology, upon the institution of a permanent International Center of Radiobiologic Studies, with headquarters in Venice, of which the "Radiobiologic Review" is the official organ. The direction of the Society is still entrusted to Mr. De Protti, and the next meeting of the Congress has been fixed for the year 1936.

MARIO PONZIO

Turin, Italy

ABSTRACTS OF CURRENT LITERATURE

CONTENTS BY SUBJECT

THE FOLLOWING ABSTRACTORS HAVE CONTRIBUTED TO THIS ISSUE

J. N. Ané, M.D., of New Orleans
G. E. Burch, Jr., M.D., of New Orleans
Hans A. Jarre, M.D., of Detroit
E. T. Leddy, M.D., of Rochester, Minnesota
Davis H. Pardoll, M.D., of Chicago
E. A. Pohle, M.D., Ph.D., of Madison, Wisconsin
Charles G. Sutherland, M.D., of Rochester, Minnesota

CONTENTS OF ABSTRACTS IN THIS ISSUE, LISTED ALPHABETICALLY BY AUTHORS

ACTINOMYCOSIS

Radiation Therapy of Actinomycosis. Otto Dyes. Strahlentherapie, 1934, **50**, 641–657.

Radiation therapy of actinomycosis is of benefit in many cases, provided that sufficiently high doses are applied. In the experience of the author it is necessary to administer approximately 600 r effective in the diseased tissue. This dose should be given within six days. Even patients with involvement of inner organs may be saved unless the destructive process has advanced too far. Iodine medication does not seem to be necessary to obtain good end-results. From a cosmetic standpoint alone roentgen therapy is superior to surgery in external lesions, particularly around the mouth and neck.

ERNST A. POHLE, M.D., Ph.D.

ARTHRITIS

The Roentgenologic Picture of Arthritis of the Cervical Spine. Luigi Bevilacqua. Arch. di radiol., 1934, **10**, 182–188.

Bevilacqua, of Padora, first discusses briefly the embryology and anatomy of the vertebral column and then takes up in detail the cervical spine. In this exposition he emphasizes especially the radiologic examination of the articular apophysis which he carries out by a particular technic which he illustrates.

E. T. LEDDY, M.D.

CANCER (THERAPY)

The Problem of Radiosensitivity. Max Cutler. Jour. Am. Med. Assn., Oct. 20, 1934, **103**, 1204–1209.

Following the discovery of x-rays and radium about thirty-five years ago, the problem passed through a preliminary experimental period of physical and biologic studies that were essential to establish the fundamental basis of radiotherapy. Physicians are only beginning to approach an understanding of some of the principles of radiotherapy and their clinical application to the treatment of cancer.

With present methods, squamous carcinoma fulfils all the criteria of the definition of a radiosensitive tumor, but this fact is not known to many pathologists and clinicians. That the microscopic structure of a tumor is only one of a group of factors which indicate the property and degree of radiosensitivity is now fully established. An estimate of radiosensitivity in relation to treatment can, therefore, be made only in consultation between the pathologist and the radiotherapeutist if erroneous and misleading deductions are to be avoided. Investigation dealing with the physiologic and biologic effects produced in normal and neoplastic tissues exposed to x-rays and radium attempts to explain the method by which irradiation effects the disappearance of tumor cells and at the same time preserves the normal structures. The response of tumors to irradiation is governed by a group of factors including physical, histologic, pathologic, and clinical, which in combination with one another determine the ultimate result. The failure to recognize the relative importance of all the principles that influence the ultimate result may lead to errors in interpretation of radiophysiologic phenomena. Observations emphasize the inadequacy of microscopic studies alone to predict the response of tumors to radiation therapy. A decision on the choice between operation and irradiation in the treatment of a given tumor is at times exceedingly difficult. Of the several factors that determine the success or failure in the radiotherapy of a given tumor, the factor of radiosensitivity is the most important.

A radiosensitive tumor may be defined as one that can be completely destroyed by a correct irradiation without permanent damage to the surrounding normal structures. The complete sterilization of a tumor by irradiation can be accomplished in two ways: (1) selective radiation and (2) caustic radiation. Selective radiation sterilizes cancer cells without causing serious damage to the surrounding normal structures. Caustic radiation not only destroys the tumor but seriously injures the surrounding normal tissues.

Carcinomas arising from the epidermoid structures of the skin and mucous membrane comply with the criteria of radiosensitivity. Outstanding examples of radioresistant tumors are adenocarcinomas, melanomas, fibrosarcomas, and osteogenic sarcomas. Carcinoma of the breast possesses an intermediate degree of sensitivity.

Regaud and Nogier (1914) and Delbet (1918) observed that when radiation is administered by repeated exposures over a prolonged interval the tumor cells become more resistant and develop a radio-immunity, whereas the normal cells become more radiosensitive and more subject to radionecrosis. It was shown experimentally that by prolonging the time of treatment the threshold of cutaneous necrosis is increased by 50 per cent, while at the same time the threshold of sterilization is maintained at its original level.

The saturation method of Pfahler and the technic of Coutard are compared and a technic of teleradium therapy, somewhat different from that of Coutard, is given in detail.

CHARLES G. SUTHERLAND, M.D.

The Present Status of Radiation in the Treatment of Cancer. Arthur C. Christie. Jour. Am. Med. Assn., Sept. 29, 1934, **103**, 985–989.

The rational basis for radiation therapy goes back to the early discovered fact that embryonal types of cells are more radiosensitive than adult forms. The shorter the life cycle of the cell the more sensitive to radiation, and *vice versa*. Lymphocytes have the shortest life cycle and are, therefore, more sensitive to radiation; bone and nerve cells have the longest life cycle and are, therefore, more resistant. Among other factors that are equally important are the general condition of the patient and his reaction to radiation, the immediate tissue environment of the cancer (the cancer bed), and the relation of the growth to vital organs or important tissues that may suffer injury.

Except in superficial cancers in which it is possible to destroy the growth by the caustic effect of radiation, the single massive dose method has been practically abandoned. Some type of fractional dose is now in general use. The "saturation method" of Pfahler consists of administering a large initial dose and maintaining the radiation effect at a maximum by giving a small daily dose until the total dosage is attained. The Coutard fractional dose method of applying the roentgen rays consists in giving a large total dose over a prolonged period (from 18 to 35 days), an equal amount being given daily until the total dose has been reached. Results have been obtained by this method which are superior to any previously thought possible. Holfelder has used a method that aims to take advantage of the large initial dose of the "saturation method" and subsequently to build up the dosage by the method of Coutard. The increased benefits from the fractionated dose method appear to arise from the improvement in the ratio between the destructive effect on the neoplasm and the reaction in the surrounding normal tissues.

Progress has also taken place in methods of radium therapy, especially in respect to interstitial radiation. The use of gold and platinum seeds was a great advance over glass seeds for the interstitial application of radon; the increased filtration lessens the danger of localized necrosis. The use of tubules, or needles from 3 to 6 cm. in length with a very small amount of radon or radium element to the running centimeter in the form of a grid, has secured a fairly uniform dosage. Further advance may be made in roentgen apparatus by securing a much greater energy output by the use of tremendously higher milliamperage rather than by an increase in voltage.

Because of results obtained in large numbers of primarily inoperable and seemingly hopeless conditions and in recurrences after operation, and because of improvements in results when used in addition to surgery, the attitude toward radiation has radically changed during the past three or four years. Cancers of the skin have been treated by radiation methods almost from the time of the discovery of the roentgen ray. The basal-cell type when it is small and does not involve cartilage or other important structures is readily curable. The fractionated method of Coutard constitutes an epochal advance in dealing with lesions involving cartilage. The primary treatment of squamous-cell epithelioma should be a thorough irradiation of the entire lymphatic drainage area by the fractional method. The added danger of dissemination must be weighed when biopsy is contemplated; it should be postponed until about two weeks after roentgen irradiation to lessen the liability of spread. If there is any residuum of the primary lesion it can be destroyed by electrocoagulation or by implanting interstitially gold or platinum radon seeds or small needles of radium element. If excision is to be done at all, it should always be preceded by irradiation.

C. G. SUTHERLAND, M.D.

Treatment of Cancer of the Breast. George W. Grier. Pennsylvania Med. Jour., October, 1934, **38**, 19–23.

The author discusses the treatment of cancer of the breast under the following subtitles: radiation without operation, pre-operative radiation, post-operative radiation, and treatment of recurrences.

It was formerly believed that radiation without operation should be confined to those cases of cancer of the breast which have been declared inoperable. Sir Berkeley Moynihan stated that he had abandoned surgery for radiation in breast cancer. However, the author believes that operable cases should have the benefit of surgery, as this procedure removes large masses of tumor tissue rapidly, saves much unnecessary radiation, and is followed by a sufficiently great percentage of permanent cures to justify the operation. The thoroughness of the surgical procedure in completely eradicating the disease should be closely followed in radiation therapy of this condition. Two cases of inoperable breast carcinoma are presented which demonstrate the possibility of completely removing large cancerous masses by roentgen-ray treatment alone.

The author's technic consists in giving an initial full dose of radiation of sufficient quality to produce an effect in all parts of the tumor. If the initial dose is not given at one sitting, but divided up into fractional doses, the time required to give the full dose should not be more than four days and the dose should be increased sufficiently to make up for the loss incident to the interval between treatments. It is considered of importance to follow the initial dose by subsequent treatment at an interval which will not allow for recovery of the tumor from the first treatment. This interval should not exceed two weeks, at which time it is necessary to compute the dissipated radiation and apply sufficient radiation to replace this dissipated radiation. This process must be continued until the cancer becomes inactive.

The object of pre-operative radiation is to devitalize the cancer cells so that they will be less likely to grow if they enter the circulation during the operation and are deposited in some distant region. The author does not believe it advisable to delay operation in order to give pre-operative radiation, and when this form of radiation is employed, he is of the opinion that the operation should not be delayed any longer than it takes the patient to recover from the roentgen sickness. The technic used consists of administering a full dose over the breast, axilla, and supraclavicular region, using 200 K.V. and 0.5 or 0.75 mm. copper filter.

Post-operative radiation is employed to destroy cancer cells that may be left after operation, and has been used by the author for a period of about twenty-five years. While there has been considerable difference in opinion regarding the value of this form of radiation, it is believed that the technic employed and the skill of the radiologist have much to do with the success of this form of therapy. Radiation of a quality produced by 135 K.V. is considered preferable to 200 K.V. for treatment of the breast area and axilla because of the

possibility of producing injury to the underlying lung with the latter technic.

Cutaneous and subcutaneous recurrences are usually sensitive to radiation if they have not been neglected and allowed to break down and ulcerate. From 120 to 135 K.V., with a filter of from 1 to 3 mm. of aluminum, is considered sufficient for these lesions. An erythema dose is applied every two weeks until the nodules disappear. In case in which the recurrent lesion is larger and from one-half to one inch in thickness it is best to use high voltage therapy at once, applying from 1,000 to 1,100 r at the initial dose, using 200 K.V. and 0.5 mm. copper filter.

J. N. Ané, M.D.

CHRONIC INFECTIONS

The Etiology of Lymphoblastoma. Arthur U. Desjardins. Jour. Am. Med. Assn., Oct. 6, 1934, **103,** 1033–1036.

The factor immediately responsible for lymphoblastomatous hyperplasia of the lymphoid structures is chronic infection of any kind. This may be tuberculous, pyogenic, or even syphilitic; in fact, the variety of infection is of little consequence, provided the infectious element has been present for a sufficiently long time. The duration of infection may vary considerably in different patients. Evidence of long-standing will be obtained in the majority of cases. The historical inquiry should be directed to trouble with the teeth, sore throat, sinusitis, repeated earache, frequent bronchial colds or disorders involving the gall bladder, gastro-intestinal and genito-urinary tracts. The practically constant association of infection and primary lymphadenopathy in the same region and on the same side of the body can hardly be regarded as a coincidence.

In a small proportion of cases (less than 10 per cent) also more or less clear indications of an antecedent tuberculous process may be noted, but in the majority of patients tuberculosis does not appear to play an etiologic part.

A predisposing factor also is required to provide a suitable background for the immediate cause. This additional and essential element is probably to be found in a hereditary predisposition or tendency, transmitted from generation to generation, of the lymphoid tissue to react in a certain way to various noxious influences.

Twelve case histories have been reviewed in detail to illustrate these contentions.

Charles G. Sutherland, M.D.

CONTRAST MEDIA

Unusual Pyelographic Observations. (Penetration into the Renal Parenchyma and Perforations.) J. Arendt and H. Brockmann. Fortschr. a. d. Geb. der Röntgenstrahlen, April, 1934, **49,** 335–341.

Several such accidents of instrumental pyelography are described, especially a fistulous tract leading off a pyonephrotic renal pelvis on the left side into the duodenum. Furthermore, tubular injections and so-called pyelovenous reflux are shown—a differentiation between these two manifestations is demonstrated on the basis of investigations by Fuchs and Minder. Finally, demonstration of the renal veins as a result of pyelovenous reflux is described, resulting possibly on account of the presence of blocking accessory vessels—arteries. All cases reported showed evidence of real renal disease. The opinion is expressed that the observations of such accidents indicate an incontinency of the renal pelvis and parenchyma to pressure in the presence of a pathologically altered renal mucosa and parenchyma.

(We are of the opinion that two factors are entirely overlooked in this article. First, absorption of contrast medium in the renal parenchyma seems possible. Such an absorbed contrast medium probably should delineate not the renal veins but more likely the renal lymphatics. Secondly, we doubt that pyelovenous reflux ever has been proven conclusively; that, on the contrary, a pyelolymphatic reflux would seem to be a much more logical explanation of some of the images discussed.)

H. A. Jarre, M.D.

Excretory Urography after Subcutaneous Injection of Neoskiodan. Edwin Beer and Frederick H. Theodore. Jour. Am. Med. Assn., July 21, 1934, **103,** 181–183.

In 1931 Butzengeiger first attempted subcutaneous injection of skiodan in adults, using a 4 per cent (isotonic) solution and injecting 500 c.c. containing 20 gm. into the axilla. In 30 cases he reported results almost as satisfactory as those obtained by intravenous injection. The maximum excretion appeared from thirty to fifty minutes after injection, and there were no local or general deleterious effects. Hillebrand used the method in 1932 to demonstrate a renal tumor without disturbance, inflammatory or necrotic, at the site of injection in the axillary tissues.

In the service at Mount Sinai Hospital 15 patients, 10 of them children, have been injected in this way with fairly satisfactory results. The best urographic shadows were obtained about fifty to sixty minutes after injection. Good urograms can be made at any time from thirty to ninety minutes after injection, in the authors' experience.

Charles G. Sutherland, M.D.

ENCEPHALOGRAPHY

Encephalography under Nitrous Oxide Anesthesia. R. W. Waggoner and L. E. Himler. Am. Jour. Roentgenol. and Rad. Ther., June, 1934, **31,** 784–786. (Reprinted by permission from the British Med. Jour., Oct. 6, 1934, Epitome of Current Medical Literature.)

The authors record 13 cases of encephalography in which nitrous oxide anesthesia obviated all subjective symptoms while the fluid was being removed, without

preventing a quick return of consciousness. This anesthetic was found also to diminish the severity of the post-encephalographic reaction. The pulse rate, blood pressure, and respiration rate were recorded every few minutes, and no adverse manifestations were noted, whereas without an anesthetic the pulse frequently becomes weak and thready after about 50 c.c. of spinal fluid has been removed. The only objection is the additional expense involved.

The increase in initial intracranial pressure consequent upon its use does not appear to be a contra-indication. The age of the patients in the authors' series ranged from 3 to 56 years. The average time required for drainage of the fluid was slightly under one hour. The authors add that no cases with choked discs or posterior fossa tumors have been included so far, although two with frontal and temporal tumors were clearly localized by this method. These two patients were up and free from headache in less than forty-eight hours.

FRACTURES

Badly Healed Fracture of the Styloid Process of the Radius Successfully Treated by Prolonged Immobilization. O. Kapel. Hospitalstidende, June 26, 1934, **77,** 786–788. (Reprinted by permission from the British Med. Jour., Oct. 6, 1934, Epitome of Current Medical Literature.)

The author finds that in certain fractures, such as those of the os naviculare manus and of the styloid process of the radius, inadequate immobilization may prevent bony union and ultimately lead to a painful wrist with chronic arthritis deformans. When immobilization is not continued long enough pain returns on movement, and it may then be waste of time to practise massage and active movements. A chauffeur, aged 49, fractured the styloid process of the right radius while cranking up a car. For three weeks the wrist was immobilized, and thereafter he was treated with massage and movements. As his wrist remained painful he was referred to the author, who secured it in plaster-of-Paris, in a position of slight dorsal flexion, with the fingers perfectly free. The patient was thus still able to do gardening. The plaster was changed every eight weeks and worn altogether for seven months, after which the movements about the wrist and fingers were perfectly free and painless. The successive x-ray examinations when the splint was changed showed progressive healing of the fracture. The author argues that if movements and massage had been continued when he took over this case, the patient would have had an always painful joint, with arthritis deformans and progressive invalidism before him.

Shadows around the Internal Condyle of the Femur. Achille Manara. Arch. di radiol., 1934, **10,** 240–249.

The author discusses in detail the differential diagnosis of these shadows and emphasizes the importance they may have not only medico-legally but in the treatment of fractures of the lower femur and lesions of the knee joint.

E. T. LEDDY, M.D.

GALL BLADDER (NORMAL AND PATHOLOGIC)

Cholecystitis and Cholelithiasis of Childhood. Howard B. Hamilton, C. O. Rich, and J. Dewey Bisgard. Jour. Am. Med. Assn., Sept. 15, 1934, **103,** 829, 830.

Potter collected 226 cases of gall-bladder disease in children under fifteen years of age, as follows: fetuses, 2; new-born infants, 12; 1-day-old infants, 9; infants, 19; less than 1-year children, 18; one-to-five-year-olds, 26; five-to-ten-year-olds, 55, and ten- to fifteen-year children, 85. Cholecystitis was associated with stones in 44, no stones in 59, with jaundice in 30, and not stated in 93 cases. Stones were present in 140, absent in 48, and not stated in 128 cases. Primary malignant neoplasms were found in two cases. Jaundice was present in 64, absent in 34, and not stated in 128 cases. The authors report a case in a boy 8 years of age. The gall-bladder wall measured 4 to 5 mm. in thickness and was densely fibrotic and somewhat edematous. It was firmly adherent to the duodenum. The mucosa of the gall bladder was markedly injected and presented small focal areas of necrosis. It contained one stone composed of bile salts. Cholecystectomy was done and the patient's convalescence was uneventful.

CHARLES G. SUTHERLAND, M.D.

The Radiology of the Gall Bladder. H. Graham Hodgson. Proc. Royal Soc. Med., September, 1934, **27,** 1473–1478.

It should be remembered that radiology is to be employed as an adjunct to clinical findings in the diagnosis of biliary tract disease. The author briefly reviews the development of radiographic studies of the gall bladder, beginning with the visualization of calculi to the present-day use of gall-bladder dye. A discussion of the technic employed in cholecystography and the interpretations of results is cited, among which an absence of the gall-bladder shadow indicates (1) that the liver is not excreting the dye, (2) that the cystic duct is blocked, or (3) that there is a breakdown through disease of one or more of the links in the concentrating chain of the gall bladder, that is, either of the mucous membrane or of the vascular or lymphatic drainage. Some of the precautions that are to be taken in obtaining the cholecystograms before rendering a diagnosis in the case of a negative or positive shadow are discussed.

G. E. BURCH, JR., M.D.

GASTRO-INTESTINAL TRACT (DIAGNOSIS)

Polisographic Studies of Pathologic Gastric Processes, with Particular Reference to the Early Diagnosis of Gastric Carcinoma. Chichio Tamiya and Shuei Nosaki. Fortschr. a. d. Geb. d. Röntgenstrahlen, September, 1934, **50,** 264–280.

In the June, 1933 issue, of this Journal the authors

published a paper in which they showed that the old method of "polygraphy" still must be regarded as a valuable technical procedure for the analysis of physiologic and pathologic motor phenomena of the stomach. They were able to confirm Fränkel's conception of localized marginal gastric rigidity and his evaluation for the recognition of ulcerative and infiltrative lesions.

The present paper is an experimental study on the stomach of cats following artificial production of tumor-like infiltrations by the injection of from 8 to 10 per cent solution of zelloidin in a mixture of alcohol and ether. From their experiments the authors conclude that lesions measuring 0.7 sq. cm., located either in the mucosa or submucosa or involving the entire thickness of the gastric wall, can be recognized in "polisograms." The criterion for their recognition, as stated in the previous paper and quite in agreement with other authors—Fränkel, Bernstein, Assmann, and others—is the localized marginal rigidity. Additional conclusions are drawn as to the occurrence of spastic retractions opposite the organic lesions, the shortening of the lesser curvature, especially the pyloric segment, with gradual extension of a pathologic process and the effects of peritoneal adhesions in extra-ventricular tumors, the two latter frequently leading to a diminution of peristalsis rather than a fixation of the gastric wall.

It is interesting to record that a method which is now nearly twenty-five years old and has been forgotten for many years, still can produce very satisfactory results in the hands of careful experimenters. As it is a very simple technical procedure, it might well be employed more frequently, not to the exclusion of more modern methods, especially the ones of relief studies, but as an addition to such valuable procedures.

HANS A. JARRE, M.D.

The Importance of Roentgenologic Examination in Diverticulosis of the Colon. Guiseppe Brancadoro. Arch. di radiol., 1934, **10,** 225–239.

Brancadoro presents three cases of diverticulosis of the colon, with various symptomatology, in which a roentgenologic examination, carried out in various ways, alone made the correct diagnosis. After a discussion of the pathogenesis and symptomatology of diverticulosis and diverticulitis, he insists on the necessity of considering diverticulosis as a possibility in obscure cases.

E. T. LEDDY, M.D.

Chronic and Productive Lesions of the Terminal Ileum Studied by Mirrored Seriography. P. Perona. Arch. di radiol., 1934, **10,** 145–181.

Perona, of Padora, having shown that the terminal ileum resembles the stomach in many ways—morphologically, functionally, and in the architecture of its mucosa—points out how frequently appendicitis is associated with catarrhal enteritis and how one condition may simulate the other. He, therefore, emphasizes the importance of a seriographic study of the mucosa of the ileum and illustrates some aspects of ileal catarrhal enteritis which reproduce in part at least the picture of chronic gastritis and colitis. Among these he points out that *follicular enteritis* has a picture which may resemble that of papillomatosis.

In conclusion, he discusses the differential diagnosis between tuberculoma and blastomatous lesions in the ileo-cecal region and points out that a study of its filling may furnish evidence about its functional and structural peculiarities which may differentiate them.

E. T. LEDDY, M.D.

GENITO-URINARY TRACT (DIAGNOSIS)

The Management of Urologic Complications in Injuries to the Spine: Report of 54 Cases without a Single Infection in the Urinary Tract. J. F. Connors and I. E. Nash. Am. Jour. Surg., October, 1934, **26,** 159.

The literature on injuries to the spine has been reviewed with especial reference to morbidity and mortality statistics both in military and civil practice.

The pathologic physiology occurring in the spinal cord and in the urinary tract is described briefly.

Infection of the urinary tract is found to be the most important cause of death in these injuries. Catheterization of the bladder is accepted as the cause for infection in the opinion of almost all commentators.

The management of the urologic complications has been outlined, stress being laid upon the absolute necessity for the avoidance of catheterization. The authors are aware that some cases are not infected by catheterization, but they feel that this is a matter of luck rather than sound judgment. They feel that twenty years of clinical experience justifies their views on this subject.

An analysis is made of 54 cases treated in Harlem Hospital without a single infection in the urinary tract.

DAVIS H. PARDOLL, M.D.

HEART AND VASCULAR SYSTEM

The Radiologic Diagnosis of Exudative Pericarditis. Benedetto Marini. Arch. di radiol., 1934, **10,** 189–207.

Marini recalls the well-known fact that in some cases a radiologic diagnosis of exudative pericarditis is very easy to make and in others very difficult, if not impossible. He illustrates four cases he studied by various methods of examination and emphasizes that it is not safe to rely on one method of examination, but that it is better to use all available clinical and roentgenologic evidence together to make the diagnosis.

E. T. LEDDY, M.D.

JOINTS

Symmetrical Serous Synovitis (Clutton's Joints): Congential Syphilis and Interstitial Keratitis. Joseph V. Klauder and Harold F. Robertson. Jour. Am. Med. Assn., July 28, 1934, **103,** 236–240.

"Clutton's joints" refers to a painless hydarthrosis,

which is not tender and is unassociated with bone changes. It usually involves the knee and may be unilateral but is more frequently bilateral. A synovitis is the primary and most important pathologic process. The condition is seen for the most part in syphilitic children and is the most common form of syphilitic change in the joints in the congenital variety of the disease. Syphilis of the joints occurring in infants is presented by inflammation secondary to involvement of the neighboring epiphysis. Serous synovitis (Clutton's joints) in adults, the subjects of acquired syphilis, is uncommon and usually precedes or accompanies the secondary eruption.

Roentgenographic examination shows no changes in the bone. The picture is merely that of a distention of the joint. Pathologically the synovial membrane is infiltrated and studded with gummas and is everywhere thickened and much more vascular than normal.

CHARLES G. SUTHERLAND, M.D.

THE LUNGS

The Estimation of Functional Disability in the Pulmonary Fibroses. William S. McCann, Alberto Hurtado, Nolan Kaltreider, and Walter W. Fray. Jour. Am. Med. Assn., Sept. 15, 1934, **103,** 810–814.

Pneumonoconiosis presents a medico-legal problem of major importance. It is essential that objective means of estimating disability be sought which will be fair alike to workmen and employer in view of the growing tendency to adjust awards of workmen's compensation to the degree of disability.

The function of respiration is one jointly mediated by the heart, the blood, and the lungs. The authors have carried out investigations on the respiratory function of 53 cases of pulmonary fibrosis, not all of which were cases of pneumonoconiosis. Their studies dealt with the pulmonary capacity and its subdivisions, with the tidal air, dead space, alveolar gases, and response of the pulmonary ventilation to exercise. They included the usual diagnostic roentgenographic studies, together with measurements of areas of the pulmonary fields during maximum inspiration and expiration, with observations as to the behavior of the ribs and diaphragm. The blood was studied in each case as to count, hemoglobin, cell and plasma volume, and gas content, particularly of the degree of saturation of the arterial blood with oxygen. The heart was carefully measured roentgenographically. Electrocardiograms were made in each case, and the cardiac output was measured in a large proportion of them. The total pulmonary capacity and its subdivisions were measured by the method of Christie.

In order to determine to what extent the roetgenograms of the lungs gave clues as to the degree of functional impairment of respiration, the cases of pulmonary fibrosis were divided into six groups, according to the anatomic type of fibrosis revealed. The comparison of the observed with the normal calculated pulmonary capacity in cases of pulmonary fibrosis indicated that a decrease in the total and vital capacities and an increase in the residual air are characteristic changes in this condition. These changes tend to become more accentuated as the degree of fibrosis increases, but frequent exceptions to this correlation emphasize the fact that one cannot judge accurately the degree of abnormality in pulmonary capacity from roentgenograms alone.

CHARLES G. SUTHERLAND, M.D.

Congenital Cystic Disease of the Lungs: A Clinical Study. Harry G. Wood. Jour. Am. Med. Assn., Sept. 15, 1934, **103,** 815–821.

Cases fall into two groups: (1) those in which there are single or multiple large cysts containing air and fluid, and (2) instances of diffuse degeneration resulting in the so-called honeycomb type of lung. The congenital origin of this disease is still a matter of contention but in many cases the lesions are palpably present at birth and, more important still, in specimens obtained in later life, pigment is absent almost invariably. No simple mechanical explanation is available for what is manifestly a developmental anomaly of which many of the factors are unknown.

Sixteen cases observed at the Mayo Clinic are reviewed in detail. In this series, the lesions were wholly or chiefly limited to the right side of the thorax in eight cases and to the left in five. In three, the lesions were bilateral and of the honeycomb type. In three of the others in which the lesions were chiefly unilateral, there was evidence of bilateral involvement. Of the thirteen cases in which the lesions were chiefly unilateral, the cysts contained fluid in five, and air in eight. Both tuberculosis and syphilis seemingly can be ruled out as etiologic factors. Thirteen patients came to the Clinic with complaints associated with the pulmonary lesions, while in three the pulmonary lesions were purely incidental.

Extensive lesions may be present with very few, or no, symptoms. The clinical manifestations vary greatly and depend chiefly on the extent of the lesions, on their site, and on whether or not there is a change in intrathoracic pressure. Most characteristic of all is a history, obtained particularly with reference to infants and children, of recurring attacks of severe dyspnea with cyanosis. Such attacks occur only when an imperfect bronchial communication exists. When progressive dyspnea develops in adults, without apparent cause, and with or without a preceding respiratory infection, the possibility of congenital cystic degeneration of the lungs should be considered. Theoretically, with increased intrathoracic pressure, the displacement of the heart and mediastinal structures should be away from the lesion. The differential diagnosis involves thoracic tumor, pulmonary abscess, empyema, dermoid cyst, and echinococcus cyst.

Bronchoscopic examination and injection of iodized oil and the injection of air into the pleural cavity have been of assistance in the diagnosis.

Complete extirpation of fluid-containing cysts;

bronchoscopic aspiration followed by injection of iodized poppy-seed oil has been useful in treatment. Diffuse, bilateral cystic degeneration of the so-called honeycomb type is not benefited by any form of treatment.

CHARLES G. SUTHERLAND, M.D.

Pulmonary Lesions Produced by Paraffin Oil. E. Ellinger. Fortschr. a. d. Geb. d. Röntgenstrahlen, April, 1934, **49**, 397–403.

Three cases are reported of rather extensive indurative pneumonic consolidation of basal pulmonary segments which were traced to prolonged instillation of rather large quantities of paraffin oil. Reference is made to a similar case reported by Fischer-Wasels in which the diagnosis was confirmed at autopsy, and also to a case reported by Bodmer and Kallós in which the diagnosis was made during the lifetime of the patient. Reports of American authors (Laughlen, Pinkerton, Pierson) are cited concerning pneumonia in children, resulting from aspiration of mineral and animal oils.

The roentgen image is not characteristic and can hardly be differentiated from other indurative pneumonic processes involving the lower lobes. A reliable diagnosis can be obtained only with due consideration of the patient's history. For differential diagnosis, one must consider tuberculosis, bronchiectases with pneumonitis, carcinoma of the bronchus, tertiary pulmonary syphilis, pulmonary lymphogranuloma, actinomycosis, and a sarcoid pulmonary tumor described by Boeck.

The prognosis of these pulmonary lesions is relatively favorable as the process is of but slow progression, even in the instance of instillation of the injurious oils which has extended over many years.

Paraffin oil in the air passages, especially for treatment of nasal and laryngeal disease, preferably should be omitted completely, and replaced by saponifiable vegetable oils.

H. A. JARRE, M.D.

The Surgical Treatment of Carcinoma of the Bronchi and Lungs. William F. Rienhoff, Jr., and Edwin N. Broyles. Jour. Am. Med. Assn., Oct. 13, 1934, **103**, 1121–1128.

The total removal of the entire lung bids fair to become eventually the operation of choice in the surgical treatment of malignant tumors of the bronchi and lungs. The development of a rational, safe, and thorough operative procedure is therefore of prime importance. The authors report two successful cases of pneumonectomy.

Incidental to the development of an operative technic for the removal of the thoracic esophagus, it became evident that compression of the lung by an artificial pneumothorax would serve two very valuable purposes, *i.e.*, first, the patients were able to adapt themselves to breathing with the non-collapsed lung and also adjust themselves to the altered conditions of intrathoracic pressure that would exist during and after the operation. Thus the shock attendant on opening the pleural cavity was negligible. The second purpose was to remove the lung mechanically as far as possible from the operative field so as to give the maximum exposure of the mediastinum with the minimum handling of the lung. The surgical procedure is described in detail.

CHARLES G. SUTHERLAND, M.D.

PNEUMONIA

X-ray Diagnosis of Pneumonia. Joseph E. Roberts. Jour. Med. Soc. of N. J., October, 1934, **31**, 568, 569.

With the use of the x-ray the various pathologic changes of pneumonia may be followed throughout the course of the disease, beginning with the stage of congestion and continuing through resolution, all of which present rather characteristic findings.

G. E. BURCH, JR., M.D.

SILICOSIS AND PNEUMONOCONIOSIS

Inhaled Silica and its Effect on Normal and Tuberculous Lungs. Leroy U. Gardner. Jour. Am. Med. Assn., Sept. 8, 1934, **103**, 743–748.

A very convincing array of clinical, statistical, and experimental observations has demonstrated that dusts composed, in whole or in part, of silica are capable of exciting a characteristic, progressive, nodular fibrosis of the lungs and that at the same time these organs become abnormally susceptible to the tubercle bacillus. All the other types of dust that have been thus far investigated can apparently be inhaled almost with impunity for long periods of time.

It was originally claimed that only uncombined or "free" silica in the form of quartz was capable of producing this effect, but in recent years there has been a growing tendency to look with suspicion on some of the silicates (combinations of silica with bases). One of these, asbestos, a silicate of magnesium, is now a well recognized cause of pulmonary fibrosis, although the reaction is diffuse and not nodular in character. Jones claims that a silicate and not free silica is the important factor in the production of all cases of silicosis. Where silicosis developed he found a fibrous silicate of aluminum and potassium called sericite in association with the quartz, and in cases in which there was no sericite there was no silicosis. Experimentally and practically, pure quartz has produced lesions essentially the same as those found in human silicosis.

Gye and Purdy demonstrated that silica in colloidal form is a cell poison, which, injected intravenously in large doses, causes almost instant death but in smaller quantities produces proliferation of connective tissue. They proposed the hypothesis that particulate silica in the form of quartz is slowly dissolved in the alkaline fluids of the body, liberating minute quantities of colloidal silica, which constitutes the irritant responsible for the proliferation of the connective tissues. Chemical proof of this is difficult, but there is considerable indirect experimental evidence which favors the chemi-

cal theory of action. Uncombined silica causes a very rapid necrosis of tissues, which is not produced by silicates and non-siliceous dusts. If the concentration of silica is too low or if the particles are larger than 4 microns in diameter, the response is less intense and no necrosis develops. Sericite produces inflammation but no necrosis; its action simulates that of granite, a mixture of silicates with quartz. Other substances containing no silica are practically inert. Cellular response to silica is due to some other property than solution, or ions liberated from free silica are more active than those from the silicates. In South Africa, Irvine has stated that about 75 per cent of all silicotic persons will die of tuberculosis and the same is probably true in this country.

The evolution of uncomplicated silicosis is depicted in the light of experimental observations and of the few early cases of human silicosis that have come to autopsy. In the first stage of the legally recognized disease, the roentgenographic examination reveals minute nodules throughout the middle portions of the lung-field, often more marked on the right side. As the condition progresses these nodules increase in size and blot out the previous prominent linear markings. In the second stage the nodular shadows become so large that they tend to become confluent and obscure all the normal markings. However, they still retain their uniform distribution and the outlines of the individual units are fairly well defined.

Human silicosis begins by damaging the pulmonary lymphatic apparatus and is followed by the development of nodular fibrosis of the parenchyma of the lungs. Silicosis specifically predisposes to infection with the tubercle bacillus. The mechanism of this action has not yet been determined, though it probably consists in some alteration of the soil rather than in changes induced in the infecting organism. Non-siliceous dusts localize about the lymphatic trunks and some of them excite the proliferation of small amounts of connective tissue (loose cellular), and they apparently do not increase susceptibility to tuberculosis. Non-siliceous dusts inhaled in combination with silica modify the action of the latter, altering the anatomic characteristics of the lesions and apparently decreasing the susceptibility to tuberculosis.

CHARLES G. SUTHERLAND, M.D.

THE SKULL (DIAGNOSIS)

The Roentgen Image of the Third and Fourth Cerebral Ventricles. O. Dyes. Fortschr. a. d. Geb. d. Röntgenstrahlen, September, 1934, **50,** 230–246.

The posterior portions of the cerebral ventricular system are not as readily demonstrable as are the anterior ones, because of escape of the contrast medium through the aqueduct when patients are in prone frontal positions. However, with a sufficient exchange of cerebrospinal fluid and air and possibly also additional introduction of lipiodol, a satisfactory demonstration of the detailed structure of the third and fourth ventricles often can be obtained. It may be desirable to include fluoroscopic observations in the technical procedures, especially of the distribution of opaque oil, with additional roentgenographic records made instantaneously during various phases of the fluoroscopic observations. Several case reports show successful diagnoses of a dural endothelioma and a glioma in the frontal lobes; furthermore, tumors of the cerebellum and the cerebral peduncles. These latter tumors produce protrusions of the posterior wall and the floor of the third ventricle and displace the aqueducts.

In several cases investigated carefully so far, a definite differentiation between tumors of the pons and the cerebellum could be made, facilitating indications for operation.

H. A. JARRE, M.D.

THE SPINE

Calcification of the Nucleus Pulposus. Armando Zuppa. Arch. di radiol., 1934, **10,** 250–261.

Zuppa concludes that (1) calcification of the nucleus pulposus is a disease entity characterized roentgenologically by an opacity in the intervertebral disc: (2) These shadows, in the lateral radiograph may be seen in the anterior or posterior portion of the disc according to the segment of the spine in which they are observed, and this is because of anatomical factors: (3) The observation of these shadows may be important in the differential diagnosis of calcification in the disc from other affections: (4) This condition is associated with ankylosing spondylitis which often accompanies it: (5) Calcification of the nucleus pulposus may be due to a lesion in the sympathetic, of toxic, infectious, or traumatic nature, which changes the lymphatic status of the disc and which produces trophic changes such as calcification of the nucleus pulposus or the intervertebral disc or calcification of all the ligaments.

E. T. LEDDY, M.D.

THYROID (THERAPY)

X-ray Treatment in Some Conditions of the Thyroid and Thymus. H. Davies. British Jour. Radiol., June, 1934, **7,** 362–371. (Reprinted by permission from British Med. Jour., Oct. 6, 1934, Epitome of Current Medical Literature.)

While admitting that x-ray therapy can show a high percentage of successful results in the treatment of over-activity and of enlargement of the thyroid and thymus glands, H. Davies believes that, if cases of thyrotoxicosis were more carefully grouped and operation were regarded as the method of choice in the secondary type, with x-ray treatment in the primary type, the results would be still better. Primary thyrotoxicosis occurring in the young adult is attended by an appreciable operative risk and an operative cure of only about 80 per cent, whereas the safer x-ray therapy can be shown by large series of cases to be just as effective. Davies considers that the indication for x-ray treatment in thyroid disease is over-activity of

the secretory epithelium, while in the thymus not only has such secretory over-activity to be considered as an indication, but also simple enlargement due to over-growth of the lymphoid tissue. A point to be emphasized is that recurrence in primary cases treated by operation is as high as 6 to 7 per cent, and this must be taken into account when considering the statistics of successful results in x-ray treatment as compared with operation.

If care is exercised, the risk of skin damage should be *nil* and the risk of myxedema negligible. Moreover, x-ray treatment has the advantage that it can be graded, whereas at an operation the amount of thyroid tissue removed is final. The author has treated with x-rays three cases of myasthenia gravis with enlargement of the thymus associated with enlargement of the thyroid and some hyperplasia. In one instance there was definite improvement after one month, persisting for eighteen months. In the other two cases there was immediate and striking improvement, but the sequel is unknown.

The amount of radiation required to produce a good effect in the thymus is small. In view of the close connection which has been shown to exist between the lymphoid tissue of the thymus and thyroid and other conditions, the thymus should receive careful attention when treatment is being undertaken.

VASOMOTOR DISTURBANCES

Roentgen Therapy of Vasomotor Disturbances of the Extremities. R. Gilbert and L. Babaiantz. Rev. Med. de la Suisse Romande, July 25, 1934, **54,** 725–741. (Reprinted by permission from British Med. Jour., Oct. 6, 1934, Epitome of Current Medical Literature.)

Owing to the action of x-rays on the sympathetic nervous system, the authors have made use of them in vasomotor and trophic diseases of the extremities, such as intermittent claudication, Raynaud's disease, etc. Paravertebral irradiations of the sympathetic ganglia and deep plexuses, either alone or combined with irradiation of the peripheral endings, have given excellent results. The authors have employed this method in eleven cases, five of which are here recorded. With a semi-penetrating moderately filtered irradiation, total doses of 500 to 800 r, spread over two to three weeks, are given in bi- or tri-weekly irradiations; 175 r is given per field at each treatment. If results are not obtained, the series is repeated after an interval of two or three weeks. Spinal irradiations are first given, and, if improvement be tardy, peripheral ones are added. For diseases of the upper extremity, irradiations are made over the cervical and two first dorsal vertebræ, and for those of the lower limbs over the tenth dorsal to the first lumbar vertebræ.

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